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Essays in Open Economy Macroeconomics

Amr Hosny
University of Wisconsin-Milwaukee

ESSAYS IN OPEN ECONOMY MACROECONOMICS

by

Amr Sadek Hosny

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ABSTRACT
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Amr Sadek Hosny

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This dissertation is comprised of three chapters in applied open-economy macroeconomics. The first chapter examines the autonomy of domestic monetary policy in the context of the renowned macroeconomic policy trilemma in open economies. The contribution is in using a time-varying parameter methodology that examines the dynamics of monetary policy independence over time and thus improves on existing literature that only provides a single estimate for the coefficients of interest, whereas it is shown that these coefficients significantly change over time as countries exhibit different exchange rate regimes and capital mobility positions, especially during the post Bretton-Woods period. The second chapter uses the Autoregressive Distributed Lag technique to investigate the exchange rate disconnect puzzle and examines how exchange rates are determined by fundamentals such as output, money supply, interest rates and prices in the context of the monetary approach to exchange rate determination. Finally, chapter three examines the effects of exchange rate depreciation on the trade balance in the case of a small open economy; Egypt using three different methods; namely the Marshall-Lerner condition, the J-curve, and the S-curve.

To My Parents

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Introduction

This dissertation is comprised of three chapters in applied open-economy macroeconomics. Specifically, the focus is on exchange rates and their interlinkages with the economy. Chapter one examines the choice of different exchange rate regimes on the conduct of monetary policy of an open economy, while Chapter two studies the determinants of exchange rate movements. Chapter three examines the effects of an exchange rate depreciation on the trade balance in the case of a small open economy; Egypt.

In *Chapter one*, we test the autonomy of domestic monetary policy in the context of the renowned macroeconomic policy trilemma in open economies. The trilemma hypothesis basically stipulates that policymakers cannot achieve the following three objectives simultaneously; 1) a fixed exchange rate, 2) free international capital markets and 3) an independent domestic monetary policy. We, therefore, examine how closely domestic interest rates follow their base country interest rate, using monthly observations of a large dataset of developed and developing countries during three different time periods characterized by different exchange rate regimes and capital controls; namely the gold standard (1870-1914), Bretton Woods (1959-1970), and post-Bretton Woods (1973-2009) eras. The contribution is in using a time-varying parameter model to examine the dynamics of the regression coefficient examining the independence of monetary policy, as well as the error correction term reflecting the adjustment speed of domestic interest rate following any short-run disequilibrium. The time-varying parameter methodology employed in this study tries to improve on existing literature that only provides a single estimate for the coefficients of interest, whereas it is shown that these coefficients significantly change over time as countries exhibit different exchange rate regimes and capital mobility positions, especially during the post Bretton-Woods period.

In *Chapter two*, we aim at explaining the fundamental determinants of movements in exchange rates. In section one, we investigate the exchange rate disconnect puzzle and examine how exchange rates are determined by fundamentals such as output, money supply, interest rates and prices in the context of the monetary approach to exchange rate determination. We use the same dataset of the seminal paper of Engel and West (2005) covering six industrialized countries with quarterly data from 1974Q1- 2001Q3, but employ different econometric techniques: the Autoregressive Distributed Lag (ARDL) approach to cointegration, we establish cointegration between exchange rates and fundamentals. Furthermore, we show that fundamentals Granger cause exchange rates, both in the short-run and the long-run. These results significantly improve on those of Engel and West which found no cointegration and Granger causality going in the opposite direction.

Finally, in *Chapter three*, we have a number of papers studying the effects of exchange rate depreciation on the trade balance in the case of a small open economy; Egypt. More specifically, we use three methods identified in the literature; namely the Marshall-Lerner (ML) condition, the J-curve, and the S-curve. The ML condition asserts that if the import and export demand elasticities sum up to more than unity, currency depreciation will have a favorable impact on trade balance. The J-curve phenomenon states that a country's trade balance, following currency depreciation, may first worsen in the short-run before improving in the long-run. Finally, the S-curve effect states that while cross-correlation coefficients between past values of the trade balance and current exchange rate could be negative, its future values could be positive. We use industry level bilateral trade data covering the period from 1994Q1 to 2007Q4 disaggregated according to the SITC classification into 59 industries (36 industries) that trade between Egypt-EU (and Egypt-US), respectively. First, we estimate price and income elasticities using cointegration techniques and find evidence for the ML condition in 39 industries for the Egypt-EU case as well as 28 industries in the Egypt-US case. In the second paper, we find evidence for the J-curve phenomenon in 24 industries that trade between Egypt-EU and 16 industries that trade between Egypt-US. Finally, we find support for the S-Curve hypothesis in 20, mostly small, industries out of the total 95 industries that trade between Egypt-EU and Egypt-US.

The following is a detailed description of the three chapters. Every chapter is discussed in three steps; the motivation and contribution, the model and results, and the conclusion.

Chapter 1: Understanding Dynamics of the Macroeconomic Trilemma in History

1.1. Motivation and Literature

Benefits of globalization do not come without cost. One example is the renowned macroeconomic policy trilemma facing policymakers in open economies. Typically, a country would like to achieve three macroeconomic policy goals. These are (1) a stable exchange rate, (2) free international capital markets and (3) independent domestic monetary policy. These three goals, however, cannot be attained simultaneously, hence the term "macroeconomic trilemma" or "impossible trinity". Theoretical underpinnings of this "Mundell-Fleming" model of fiscal and monetary policy in open economies are in Mundell (1963) and Fleming (1962). A direct implication is that countries pegging their exchange rates and unrestricting their international capital flows will not be able to independently conduct a monetary policy oriented towards domestic goals. Such country's monetary policy will have to follow that of its base country; the country to which its exchange rate is pegged.

When it comes to empirically testing the implications of the trilemma, a number of questions arise. First, what is the definition or measure of the three policy goals? We classify exchange rates into pegs and non-pegs, international capital markets into open and closed, and we examine how closely local interest rates follow the world (base country) interest rates as our measure of domestic monetary policy independence. The second, and more important, question has to do with the appropriate econometric methodology to be used? Our empirical test examines how different exchange rate regimes and international capital controls influence domestic monetary policy, by examining the degree to which domestic interest rates follow their base country interest rate.

We test the trilemma hypothesis for a large dataset of developing and developed countries during three different time periods characterized by different exchange rate pegs and capital controls; namely the gold standard (1870-1914), Bretton Woods (1959-1970), and post-Bretton Woods (1973-2000) eras. We test the trilemma predictions using three different approaches. The first is a simple regression equation of domestic interest rates (R_{it}) on base country interest rates (BR_{it}), both expressed in their first-difference to avoid problems of non-stationarity as follows:

$$\Delta R_{it} = \alpha + \beta\, \Delta BR_{it} + \varepsilon_{it} \tag{1.1}$$

Obstfeld et al (2005a,b) run this simple OLS under the three different eras grouping observations by exchange rate regime and capital control status and examine the magnitude and significance of the regression coefficient and the overall model fit. As such, one would expect the highest regression coefficient to be reported under periods or observations characterized by pegged exchange rates and open capital markets as this combination would lead to the lowest autonomy of domestic monetary policy as conjectured by the trilemma. While this approach is desirable in its simplicity, it leaves a number of unanswered questions. First, results for averages across countries within every era, not individual countries, are reported as observations are pooled in a panel form. And second, there is no distinction in the analysis between the long-run versus the short-run.

Some studies in the literature including Frankel et al (2004) and Obstfeld et al (2005b) examine the *level* relationship between domestic and base country interest rates in an attempt to avoid the drawbacks of the OLS approach. As such, they employ cointegration and error correction analyses to examine the long-run level relationship between the two interest rates versus the short-run dynamics and adjustment speed of the domestic rate. The focus here is on the short-run regression coefficient and the lagged error correction term from the error correction equation. The sign, magnitude and significance of the coefficient on the lagged error correction term indicate the speed of adjustment of the local interest rate following any shock to the base rate. A faster speed of adjustment to the long-run equilibrium path implies a less independent domestic monetary policy.

In this chapter, we are interested in the dynamics of the *regression coefficient* examining the independence of monetary policy over time, as well as the dynamics of the coefficient on the *error correction term* reflecting the adjustment speed of domestic interest rate following any short-run disequilibrium from the long-run path. The trilemma hypothesis stipulates that monetary policy independence changes if the exchange rate regime and capital control status change. Thus, our argument is that the existing literature that uses methodologies that only report a single estimate for the above two coefficients of interest is rather impractical. This is especially true during the post-Bretton Woods era, which covers more than thirty years of data, where we report evidence that countries alternated between open and closed capital markets over time. We also present evidence, throughout all three periods, that countries have continuously shifted from flexible to fixed exchange rate regimes and vice versa. We extend the post-Bretton Woods period studied in Obstfeld et al (2005b) to include data up to 2009 and re-test the trilemma hypothesis using OLS and error correction techniques. We then test the stability of the estimated coefficients over time and show that they exhibit significant structural breaks and are indeed unstable, thus re-enforcing our argument against existing findings in the literature. Our contribution is that we employ a new approach to test the implications of the macroeconomic trilemma hypothesis; a time-varying parameter (TVP) methodology that can capture changes in the autonomy of monetary policy, given changes in the exchange rate regime and capital control status over time.

The TVP methodology uses maximum likelihood and the Kalman filter to estimate coefficients that can vary over time. A general finding is that the time-varying coefficients for monetary policy independence show higher volatility in periods of flexible rather than fixed exchange rates. This observation holds true over the three time periods under investigation and regardless of the capital control status. For the gold standard and Bretton Woods eras, most of the variation in monetary policy independence was due to variations in the exchange rate regime rather than changes in capital control conditions. Specifically, we were able to capture the effect of a change in the exchange rate regime on the autonomy of monetary policy in a number of countries within each era.

An example is the weakening of monetary policy autonomy in the case of France during the gold standard era, where we show that the French Franc has been weakly pegged to the Sterling pound in the early years of the gold standard era, with the peg gaining strength as we move to the end of the period. Germany and the United Kingdom, on the other hand, are two countries that experienced increasing monetary independence over time during the Bretton Woods era as their peg against the US dollar weakened over time.

Our methodology also becomes pertinent when analyzing the post-Bretton Woods era as countries freely switched exchange rate regimes and capital control conditions, unlike the rather rigid nature of the previous two periods. We are able to identify periods of increasing and decreasing monetary policy independence as countries experienced different exchange rate regimes and international capital mobility restrictions over time. One example is Austria, where we were able to capture the weakening in the country's monetary autonomy over time as its initial non-peg and closed capital market policies switched to a pegged exchange rate and more open capital markets near the end of the period. We also present evidence of "fear of floating" in some countries. According to Calvo and Reinhart (2002), these are countries that continue to follow their base country interest rates even after they switch from a fixed to a more flexible exchange rate regime. In sum, this paper presents evidence in support of a "time-varying macroeconomic trilemma" in history.

1.2. Data

This section describes the data definitions and sources used in this study. The macroeconomic policy trilemma rests on three pillars, and we discuss each in detail below.

1.2.1. Exchange Rate Regimes

As mentioned earlier, we have three distinct eras. We use monthly end-of-period exchange rates in all periods. In the Gold Standard era starting from 1870M1-1914M6, we determine the exchange rate coding in two alternative ways. On one hand, a *de jure classification* is based on the country's announcement of its legal commitment to gold. On the other hand, the *de facto classification* is based on the actual behavior of the exchange rate of a country against the exchange rate of its base country. The base country for the gold standard era is the United Kingdom. Specifically, we follow the de facto coding methodology developed by Shambaugh (2004) and used by Obstfeld et al (2005b), where we check whether the end-of-month exchange rate of each country stays within a ±2% band over a whole year against the Sterling pound. We have data available for 15 countries during the gold standard era.[1]

During the Bretton Woods period between 1959M1-1970M12, and following the de facto classification of Shambaugh (2004) with the U.S.A. being the base country, we collect data for 16 countries from the IMF International Financial Statistics (IFS)

[1] The de jure and de facto classification systems are in general very similar. For Denmark, France, Germany, Norway, Switzerland and Sweden they are exactly the same.

database. Most countries are pegged to the U.S. dollar during this period, with the exception of Brazil and only a year or two for a few other countries as listed in Table (2) in the appendix. For the post-Bretton Woods era, we follow the de facto exchange rate classification of Shambaugh (2004) for data extracted from the IFS and available from 1973M1-2009M12.[2] Again, a particular country is considered to have a fixed exchange rate (peg) with its base country in any given year if its bilateral exchange rate stays within a ±2% band. Base countries include major countries such as the United States, Germany, France and the United Kingdom, as well as those that are important within a given region, such as Australia, Malaysia and South Africa. We have data for 88 countries in this era. Appendix Tables (A1)-(A3) at the end of this chapter show the exchange rate regimes classification for the three periods, respectively.

1.2.2. Capital Control Status

Due to lack of sufficient data before the post-Bretton Woods era, we follow Obstfeld et al (2005b) and assume that all capital markets are open during the Gold Standard era, and all are closed/controlled during the Bretton Woods era. During the post-Bretton Woods era, we adopt information on capital restrictions from various issues of the IMF Annual Exchange Rate Arrangements and Exchange Restrictions annual reports, as done by Shambaugh (2004) and Obstfeld et al (2005b).

[2] Obstfeld et al's (2005b) paper uses data up to 2000 only for the post-Bretton Woods period.

1.2.3. Monetary Policy

In order to measure monetary policy dependence or independence based on the hypothesis of the macroeconomic policy trilemma, we examine how closely the domestic interest rate of a country follows the interest rate of its base country. Base countries are the United Kingdom for the gold standard era, the U.S.A. for the Bretton Woods era, and they differ across countries as mentioned above, and shown in table (A3) in the appendix at the end of this chapter, for the post-Bretton Woods era.

Monthly interest rate data for the gold standard era comes from Neal and Weidenmier (2003) and were made available by Shambaugh (2004). Monthly interest rates for the other two periods are either money market rates or treasury bill rates, both collected from the IMF's IFS database. In deciding which rate to choose, we depend on data availability or choose the interest rate with the longer time series. We express all interest rates as $ln(1+R)$, where R is the interest rate reported from the data source. As explained by Obstfeld et al (2005), this transformation reduces the impact of country outliers. In addition, episodes with hyperinflation are dropped from our data set, as they might distort the regression results. Specifically, countries experiencing hyperinflation periods are Argentina, Bolivia, Brazil, Mexico, Poland, Romania, Turkey, Zambia and Zimbabwe.

The above information for the three elements of the macroeconomic policy trilemma is presented in tables (A1) through (A3) in the appendix at the end of this chapter, where each table presents data for one of the three different eras under investigation.

1.3. Econometric Methodology and Results

We examine three alternative approaches to test for monetary policy independence in the context of the macroeconomic policy trilemma. Since our objective lies in examining the behavior of a country's interest rates, we are likely to face the problem of spurious regressions if we run the regressions in levels as interest rates are macroeconomic variables that are mostly non-stationary.[3] Therefore, in our first econometric exercise, we apply first-difference regressions on pegged versus non-pegged observations across and over the different time periods. Secondly, we make use of recent developments in the time-series techniques that allow us to test for level relationships between cointegrated variables, regardless of the order of their cointegration. For this purpose, we use the Autoregressive Distributed Lag *(ARDL)* approach to cointegration developed by Pesaran et al (2001). This procedure, although attractive from an econometric point of view, still delivers a single estimated coefficient for every regression, some of which cover periods of more than 40 years. We present evidence, as detailed below, that such estimates do not accurately reflect the dynamics of monetary autonomy of any given country as countries have experienced different capital control conditions and exchange rate regimes over time. The third approach that we suggest is, therefore, a time-varying parameter methodology that allows our estimate of monetary independence to vary over time.

[3] Obstfeld et al (2005b) applied unit root tests on country interest rates over the three periods, and found evidence of both stationary and non-stationary interest rates.

1.3.1. The Difference Regressions

A major problem with nominal interest rates is that they are usually non-stationary time-series processes. In order to avoid the possibility of spurious regression, we first-difference the data and estimate the following equation:[4]

$$\Delta R_{it} = \alpha + \beta\, \Delta BR_{it} + \varepsilon_{it} \qquad (1.2)$$

where R is the domestic interest rate of country i at time t, BR is country i's base country interest rate as defined above and Δ is the difference operator. The idea is to test the degree to which a country's domestic interest rate follows its base country's interest rate over three different time periods that are characterized with different exchange rate and capital control systems. Therefore, examining the significance and sign of $\hat{\beta}$ above, serves as a simple yet subtle test for the hypothesis that a country can only simultaneously achieve two of the three objectives in context of the macroeconomic policy trilemma. In other words, in a country with an open capital market and a pegged exchange rate, we expect $\hat{\beta}$ to be close to 1 and statistically significant implying low monetary autonomy. If, on the other hand, the country exhibits a controlled capital market and/or a flexible exchange rate system, then one would expect a statistically insignificant $\hat{\beta}$, regardless of its sign.

Results are presented in Tables (1.1) and (1.2) below. We start with across and within era comparisons. Then, we pool the data across the three eras, and directly test the

[4] If a variable has a unit root (is non-stationary), then the OLS estimates will be biased downward and the reported standard errors will be tighter than the actual, leading to over-rejection.

influence of exchange rate regimes and the capital control status on the autonomy of domestic monetary policy. Considering across era variations, we can see that although the $\hat{\beta}$ coefficients on pegged observations are always higher than non-pegged ones, they are only significantly different from zero in the gold standard and post-Bretton Woods eras. This implies that the capital controls that characterized the Bretton Woods era allowed countries significant control over their domestic monetary policies. Results also reveal that the $\hat{\beta}$ coefficient during the gold standard era is higher than during the post-Bretton Woods period. This can be easily explained by the fact that capital markets, the third element of the macroeconomic policy trilemma, were open for all countries during the gold standard era, whereas there were significant capital controls during the post-Bretton Woods era. The within-era comparisons will help reveal information about the influence of the exchange rate regime on the extent to which a country follows the base-interest rate. The across-era comparisons show the role of capital controls and of different attitudes toward macroeconomic management. These results are presented in Table (1.1).

Table 1.1: Difference Regressions on Annual Data

Statistic	***Pool***	***Pegs***	***Non-pegs***
	Gold Standard – De Jure Classification		
No. of observations	491	351	139
β	.391 ***	.511 ***	.079
std error	(.040)	(.045)	(.063)
R^2	.19	.30	.012
	Gold Standard – De Facto Classification		
No. of observations	491	380	58
β	.391 ***	.482 ***	.100
std error	(.040)	(.042)	(.122)
R^2	.19	.29	.013

Statistic	*Pool*	*Pegs*	*Non-pegs*
		Bretton Woods	
No. of observations	130	115	15
β	.001	.056	-.016
std error	(.202)	(.134)	(.917)
R^2	.0001	.001	.000
		Post-Bretton Woods	
No. of observations	2226	910	1316
β	.279 ***	.392 ***	.199 ***
std error	(.038)	(.040)	(.058)
R^2	.02	.12	.006

*** Significant at the 1% significance level, ** Significant at 5%, * Significant at 10%
Robust standard errors are in ()

Secondly, we pool the data across the three eras, and directly test the influence of exchange rate regimes and the capital control status on the autonomy of domestic monetary policy. Specifically, we run regression equation (1.2) under the four possible combinations of our exchange rate regimes (pegged and non-pegged) and capital control status (open and closed). Results in Table (1.2) are perfectly in line with the macroeconomic trilemma hypothesis and indicate that the countries with a combination of pegged exchange rates and closed capital markets experience the highest monetary policy independence. Domestic monetary autonomy decreases if different regimes are adopted. Specifically, non-pegs with open capital markets and pegs with closed markets provide some domestic interest-rate autonomy. Furthermore, countries with pegged exchange rate regimes and open capital markets suffer the least monetary policy autonomy of all.

Table 1.2: Difference Regressions on Annual Pooled Data

Statistic	***Peg and Open Capital***	***Peg and Closed Capital***	***Non-peg and Open Capital***	***Non-peg and Closed Capital***
No. of observations	634	787	581	845
β	.404 ***	.395 ***	.273 ***	.159 **
std error	(.075)	(.041)	(.101)	(.069)
R^2	.143	.141	.010	.004

*** Significant at the 1% significance level, ** Significant at 5%, * Significant at 10%
Robust standard errors are in ()

A final observation from the above results is the statistically significant $\hat{\beta}$ coefficient for the non-peg and open capital regime in the fourth column in Table (1.2). This is the so called "fear of floating" concept originally studied by Calvo and Reinhart (2002). Similar results have been found by Obstfeld et al (2005b) and Frankel et al (2004). According to this view, many countries, even if formally floating their exchange rates, may in fact follow the monetary policy of their base countries or major trading partners, much as those with direct pegs. This fear of floating or more generally the fear of large currency swings, as argued by Calvo and Reinhart (2002), are more prevalent in emerging market economies facing credibility problems, inflation targets and/or a high exchange rate pass through effects from exchange rates to domestic prices. These practices are also seen for countries coming out of currency crises or episodes of high inflation, so they tend to control their interest rates to smooth fluctuations in their exchange rates in fear of falling once again in the same economic downturns. Of course, this fear of floating would be more apparent in countries with open capital markets, than in countries with strict capital controls. Our results from Table (1.2) do confirm this ($\hat{\beta}$

coefficients and R^2 are 0.2733 and 0.01 for non-peg open capital regimes as opposed to 0.159 and 0.004 for non-peg closed capital regimes).

1.3.2. The Times-Series Evidence: A Bounds Testing Approach

After getting an initial understanding of how *changes* in domestic interest rates follow changes in their base country rates, we now turn to the estimation of the *level* relationship between the two variables. For this purpose, we use cointegration and error correction analyses to differentiate between the long-run as well as the short-run relationship between the two variables. We can also explain the adjustment process of the domestic interest rate of a country towards its base country rate shedding light on the degree of independence of monetary policy of the country in the context of the macroeconomic trilemma. We follow the methodology developed by Pesaran et al (2001) and begin by estimating the following long-run model using the Autoregressive Distributed Lag (ARDL) procedure as follows:

$$R_{it} = c + \gamma\, BR_{it} + u_{it} \qquad (1.3)$$

Again, R is the domestic interest rate of country i at time t, BR is country i's base country interest rate, and γ represents the *long-run levels relationship* between the two variables. Since we are interested in studying the cointegration relationship between the domestic and base country interest rates, we re-write equation (1.3) in a constrained error-correction format. In doing so, we are able to distinguish the long-run from the short-run effects of base country rates on domestic interest rates. Specifically, the bounds testing approach of Pesaran et al (2001) specifies the following $ARDL(n_1,n_2)$ specification:

$$\Delta R_{it} = \alpha + \sum_{k=1}^{n1} \mu\, \Delta R_{i,t-k} + \sum_{k=0}^{n2} \beta\, \Delta BR_{i,t-k} + \theta_1 R_{it-1} + \theta_2\, BR_{it-1} + \varepsilon_{it} \qquad (1.4)$$

In this framework, the short-run coefficients (attached to first-differenced variables) and the long-run coefficients (attached to lagged level variables) are simultaneously estimated by applying Ordinary Least Squares to equation (1.4). The long-run coefficients are produced by using $\hat{\theta}_2$ and normalizing it by $\hat{\theta}_1$.[5] Of course, we need to establish cointegration among the variables for the long-run coefficients to be valid. Pesaran et al (2001) propose the standard *F-test* for the joint significance of lagged level variables for the cointegration test, with new non-standard critical values that they tabulate in their paper.

An advantage of this procedure is that it is applied irrespective of whether the variables are *I(1)* or *I(0)*. We can thus avoid all pre-unit-root testing associated with the standard cointegration approach of Johansen and Juselius (1990). Specifically, Pesaran et al (2001) report two sets of critical values; an upper bound critical value assuming all variables are *I(1)*, and a lower bound assuming all are *I(0)*. If the calculated F-statistic is above the upper bound, then the variables are jointly significant indicating long run cointegration. If the calculated statistic is below the lower bound critical value, there is no

[5] See Bahmani-Oskooee and Tanku (2008) for a step-by-step explanation of the method and normalization procedure. It is worth noting that the standard error of the ratio of two coefficients is not the ratio of two standard errors. Pesaran and Pesaran (1997, pp.394-404) illustrate how the standard errors of normalized coefficients are calculated using non-linear least squares and the Delta method.

cointegration. If, however, the calculated F-statistic lies in between these two bounds, then the results are inconclusive. Following Pesaran et al (2001), we calculate an error correction term, *ECT*, from the long-run equation (1.3), replace the linear combination of lagged level variables in equation (1.4) by ECT_{it-1} and estimate each model after imposing the same optimum lags.

$$\Delta R_{it} = \alpha + \sum_{k=1}^{n1} \mu\, \Delta R_{i,t-k} + \sum_{k=0}^{n2} \beta\, \Delta BR_{i,t-k} + \theta\, ECT_{it-1} + \varepsilon_{it} \qquad (1.5)$$

In this specification, one can examine the direction and speed of adjustment in the model following any short-run disequilibrium by examining the sign and statistical significance of the ECT_{it-1} coefficient. The ECT_{it-1} basically links the long-run equilibrium implied by the cointegration relationship with the short-run adjustment process describing the mechanism by which the variables react following any shock that takes them off the long-run equilibrium. In the context of equation (1.5) above, a negative and statistically significant $\hat{\theta}$, indicates adjustment of the domestic interest rate toward its long-run equilibrium as indicated by the base country interest rate following any short-run disequilibrium. Also, the higher the absolute value of $\hat{\theta}$, the faster the adjustment process or the convergence rate, which would imply less monetary independence in the context of the macroeconomic trilemma.

We now estimate equations (1.3)-(1.5) above. In choosing the number of lags, one usually minimizes the Akaike Information Criterion (AIC), imposing a maximum of 6 lags since we’re using quarterly data following Bahmani-Oskooee and Tanku (2008) among others. In what follows, we restrict the $ARDL(n_1,n_2)$ to an $ARDL(1,1)$ for simplicity and for purposes of estimating the time-varying model, as will be shown in the fourth section of this chapter. The results, however, are very similar if we impose no restrictions.[6] Results for country averages are reported in Table (1.3) below, while detailed individual country regressions are in Table (A4) in the appendix.

Table 1.3: ARDL Regressions

	γ	*β*	*θ*	*Half life*	*F*	*Stability*	*Adj R^2*
			Gold Standard – De Jure Classification				
Pegs (average)	0.40	0.23	-0.17	8.80	24.80	26.11	0.18
Occ. pegs (average)	0.51	0.07	-0.14	9.03	37.35	22.36	0.12
Non-pegs (average)	0.65	0.09	-0.18	3.49	34.30	23.66	0.15
			Gold Standard – De Facto Classification				
Pegs (average)	0.47	0.18	-0.17	8.90	29.56	20.86	0.17
Occ. pegs (average)	0.16	0.08	-0.10	11.96	27.42	22.39	0.08
			Bretton Woods				
Pegs (average)	0.57	0.06	-0.12	5.42	3.55	4.64	.08
Non-pegs (average)	0.70	-0.64	-0.04	16.98	1.30	3.58	.03
			Post-Bretton Woods				
<u>*ERR*</u>							
Pegs (average)	0.60	0.17	-0.10	10.68	10.12	10.11	0.11
Occ. pegs (average)	0.80	-0.01	-0.09	22.36	9.32	13.04	0.08
Non-pegs (average)	1.31	0.36	-0.05	36.74	6.70	8.96	0.04
<u>*Capital Market*</u>							
Open (average)	1.22	0.07	-0.14	19.65	9.29	10.15	0.20
Occ. (average)	1.22	0.18	-0.08	29.64	8.71	12.69	0.05
Closed (average)	0.75	0.26	-0.07	24.40	8.15	9.03	0.07

*** Significant at the 1%, ** at the 5% and * at the 10% significance level
The Average Wald F-statistic is reported for the stability (Quandt-Andrews breakpoint) test
Half-life is calculated as follows: $\ln(0.5)/\ln(1-|\theta|)$

[6] Full results are available from the authors.

Due to the vast amount of individual country results, we have grouped countries into pegs, occasional pegs and non-peg countries. Pegged countries are countries whose exchange rates are pegged throughout the entire period under consideration. Likewise, non-pegged countries are those with non-pegged exchange rates across the whole period. Finally, we define a group of countries under the occasional peg category, and those are countries whose exchange rates experience both and/or flip back and forth between peg and non-peg activity. This classification is based on the data available in Tables (A1) through (A3) in the appendix. We then average the respective coefficients for all countries in the same category and report that average at the end of each era. Table (1.3) reports estimates of the long-run coefficients $(\hat{\gamma})$, short-run coefficients $(\hat{\beta})$, speeds of adjustment $(\hat{\theta})$ and overall explanatory power of the model *(Adjusted* R^2*)*. We also report half-life estimates, which tell how quickly local interest rates adjust to restore their long-run equilibrium relationship with their base country interest rates following any short-run disequilibrium or shocks to the base rate.[7]

The ***gold standard era*** is an era characterized by open capital markets. Therefore, one would expect pegged countries to show the least monetary independence, followed by occasional peg countries, and finally non-peg countries should exhibit the highest monetary dependence. This should be reflected by the magnitudes and statistical significance of the long-run (γ), short-run coefficients $(\hat{\beta})$, speeds of adjustment $(\hat{\theta})$, half-life estimates and explanatory power *(Adj.* R^2*)*. According to the macroeconomic policy

[7] Half-life is calculated as: ln(0.5)/ln(1-$|\hat{\theta}|$) where $|\hat{\theta}|$ is the absolute value of the coefficient on the lagged error correction term, ECT_{it-1}.

trilemma, one would expect pegged and open capital market countries to show the highest ($\hat{\gamma}$) and ($\hat{\beta}$), ($|\hat{\theta}|$), (*Adj.* R^2) and fastest half-life estimates.

Looking at the findings from table (1.3), one can notice a considerable difference in the results between the de jure and de facto classifications. The *de jure classification* results do not seem to follow the predictions of the trilemma, as the long-run cointegrating coefficients are the lowest for pegged countries, and highest for non-pegged countries (0.40 for pegged, 0.51 for occasional peg and 0.65), the exact opposite of what one would expect. Similarly, the speeds of adjustment as indicated by the half-life estimates are slow for pegged countries and fastest for the non-pegged ones (8.80 months for pegged, 9.03 months for occasional peg and 3.49 months for non-pegged countries). Again, the opposite of what one would expect. Results of the *de facto classification*, however, are more consistent with the trilemma hypothesis. The ($\hat{\gamma}$) coefficients representing the cointegrating (long-run) relationship between the local and base country interest rates are 0.47 and 0.16 for pegged and occasional pegged countries, respectively. Short-run coefficients, on average, are also larger for pegged countries, and local interest rates adjust to their long-run path faster in pegged versus occasional pegged countries (half-life estimates are 8.90 months and 11.96 months for pegged and occasional pegged countries, respectively). Moreover, changes in base country interest rates have more explanatory power in explaining changes in local rates in pegged versus occasional pegged countries as evident from the reported *Adj.* R^2 (0.17 for pegged and 0.08 for occasional pegged countries, on average). This finding, consistent with the "fear of floating" concept of Calvo and Reinhart (2002), leads one to conclude that what countries announce as their official exchange rate regimes (de jure classifications) may not be entirely accurate, and that one should look into the actual behavior of countries' exchange rates (de facto classifications) and use that to be able to accurately define different exchange rate regimes over time.[8]

Moving to the ***Bretton Woods era***, we do not find much within era variation, as almost all countries pegged their exchange rates against the U.S. dollar along with controls on their capital markets. The only exception is Brazils' non-pegged exchange rate regime throughout the entire period, and indeed, Brazil shows significant monetary independence. Its estimated coefficient on the long-run level relationship, $(\hat{\gamma})$, is insignificantly different from zero, its speed of adjustment is rather slow (half-life of 16.98 months) as indicated by the magnitude of the estimated coefficient on the lagged error correction term, $(\hat{\theta})$ and finally the explanatory power of the model is rather weak as indicated by the model's poor fit (*Adj.* R^2 of 0.03). For the remaining sample of countries, one would expect the degree of monetary independence to differ with the degree of capital control. Strict capital controls were in place in countries like Austria, India, Jamaica, Japan, Pakistan, South Africa and Trinidad and Tobago due to their slow adjustment speeds and since their estimated level relationship, $(\hat{\gamma})$, is either negative or statistically insignificant. Finally, averaging over all countries, we can see that pegged countries show significant long-run relations $(\hat{\gamma})$, positive short-run coefficients ($\hat{\beta}$ is 0.06 versus -0.64 for non-pegs), faster speeds of adjustment ($\hat{\theta}$ is -0.12 versus -0.04 for non-pegs), lower half-life estimates (5.42 versus 16.98 months for non-pegs) and higher

[8] This is apparent in countries like Austria, Italy, Netherlands and Spain, which de jure are on a non-pegged or occasional pegged regime, but de facto follow their base country interest rate quite closely as shown by stronger level relationships and faster speeds of adjustment.

explanatory power (*Adj.* R^2 is 0.08 versus 0.03 for non-pegs) as one would expect following the hypothesis of the macroeconomic policy trilemma.

Regarding the ***post-Bretton Woods era***, we have a big number of countries with different exchange rate and capital control regimes allowing for significant within era variation. Regarding the exchange rate regime, pegged countries, on average, are reported to have the fastest speed of adjustment (half-life of 10.68 versus 22.36 and 36.74 months for occasional pegs and non-pegs, respectively) and biggest model fit (*Adj.* R^2 of 0.11 versus 0.08 and 0.04 for occasional pegs and non-pegs, respectively).[9] These results concur with the trilemma predictions. It is also worth noting that negative long-run level relations, mostly all belonging to non-pegged and occasionally pegged regimes, are all insignificantly different from zero.

Across eras, pegged countries had the fastest adjustment speed during the de facto gold standard era ($\hat{\theta}$ is -0.17 compared to -0.12 and -0.10 during the Bretton Woods and post-Bretton Woods eras, respectively). This seems obvious as that period was characterized by perfectly open capital markets for all countries involved, while they were completely and partially closed during the Bretton Woods and post-Bretton Woods periods, respectively. When it comes to occasional peg and non-pegged countries, adjustments speeds are slower for the post-Bretton Woods era (22.36 and 36.74 months) than in any other (16.98 and 13.16 months for the Bretton Woods and gold standard eras, respectively). We can also note from Table (1.3) that in almost all equations reported, the

[9] Similar results are obtained if we only include significant estimated coefficients to calculate averages across the different exchange rate regimes.

($\hat{\theta}$) coefficient on the lagged error correction term, ECT_{it-1}, has been negative and highly statistically significant. This implies that following any shock or disequilibrium from the long-run path, it is the local interest rate that adjusts to restore the equilibrium not the base rate. Furthermore, we have performed a number of diagnostic tests along the lines of Bahmani et al (2005) to show that our models are correctly specified. Results reveal that the models are mostly free from serial correlation and misspecification as indicated by the *Lagrange Multiplier* (LM) and *Ramsey's RESET* tests.

Finally, we use the Andrews (1993) and Andrews and Ploberger (1994) methodology to test for parameter instability over time. This test basically performs a Chow breakpoint type of test at every observation between two dates. These Chow test statistics are then summarized into a single statistic that tests against the null hypothesis of no structural breakpoints between the dates.[10] Results, as can be seen from the Quandt-Andrews test statistic reported in Table (1.3) mostly reject the null hypothesis of no structural breaks indicating that most parameters are unstable.[11] This is true for all three eras under investigation, but especially evident for the post-Bretton Woods period. Such a result is expected as this relatively long period must have witnessed changing economic conditions for different countries over time. This result motivates our contribution to the literature in the following section, and highlights our effort to conduct a time-varying

[10] The average Wald F-statistic that we report in Table (3) is computed as the simple average of the individual F-statistics which in turn are computed from a Wald test of the restriction that the coefficients on the equation parameters are the same in all subsamples examined. Distribution of these tests is non-standard and the asymptotic p-values are provided in Hansen (1997).

[11] We have also performed the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMSQ) tests of Brown et al (1975) as tests of parameter instability. They largely concur with those of the Quandt-Andrews test.

parameter methodology to more accurately capture the dynamics of the macroeconomic policy trilemma over time.

1.3.3. The Time-Varying Trilemma: A State-space Approach

We now allow all the parameters to vary with time following the procedure developed by Kalman (1960) and explained in Kim and Nelson (1998). Kim and Nelson (1989) were among the first to apply this methodology to model a time-varying monetary reaction function of the Federal Reserve. In the context of the trilemma, we estimate the following set of equations for every country:

$$\Delta R_t = \alpha_t + \mu_t \Delta R_{t-1} + \beta_t \Delta BR_{t-1} + \theta_t ECT_{t-1} + e_t \tag{1.6}$$

$$\alpha_t = \alpha_{t-1} + v_t,\ \mu_t = \mu_{t-1} + u_t,\ \beta_t = \beta_{t-1} + \eta_t \text{ and } \theta_t = \theta_{t-1} + \zeta_t \tag{1.7}$$

The only difference between equations (1.5) and (1.6) is the addition of a subscript t to the parameters in equation (1.6). Equations (1.7) represent the dynamics of the time-varying parameters. We use the ECT_{it-1} series estimated from the previous section, and now shift our attention to the behavior of the parameters over time. In doing so, we aim to capture the essence of the macroeconomic policy trilemma in a more dynamic setting. The extensive flipping back and forth between flexible and fixed exchange rate regimes, the strengthening and loosening of capital controls over time as evident from the data presented in Tables (A1) through (A3) in the appendix and the results of the Quandt-Andrews parameter instability tests motivate our analysis in this section.

We apply the Kalman filter within the context of a state space approach to model the dynamic time-series in equations (1.6) and (1.7) and estimate the time-variation in the parameters. The state space representation of the above equations is as follows:

$$\Delta R_t = [1 \quad \Delta R_{t-1} \quad \Delta BR_{t-1} \quad \Delta ECT_{t-1}] \begin{bmatrix} \alpha_t \\ \mu_t \\ \beta_t \\ \theta_t \end{bmatrix} + e_t \tag{1.8}$$

$$\begin{bmatrix} \alpha_t \\ \mu_t \\ \beta_t \\ \theta_t \end{bmatrix} = \begin{bmatrix} 1000 \\ 0100 \\ 0010 \\ 0001 \end{bmatrix} \begin{bmatrix} \alpha_{t-1} \\ \mu_{t-1} \\ \beta_{t-1} \\ \theta_{t-1} \end{bmatrix} + \begin{bmatrix} v_t \\ u_t \\ \eta_t \\ \zeta_t \end{bmatrix} \tag{1.9}$$

In matrix form, equations (1.8) and (1.9) can be more compactly written as:

$$\underset{(n\times 1)}{\Delta R_t} = \underset{(n\times m)}{X_{t-1}} \underset{(m\times 1)}{\beta_t} + \underset{(n\times 1)}{e_t} \tag{1.10}$$

$$\beta_t = F\, \beta_{t-1} + v_t \text{ with } F = I_m \tag{1.11}$$

$$e_t \sim iid\ N\,(0,\sigma_e^2),\ v_t \sim iid\ N\,(0,\sigma_v^2) \text{ and } E[e_t\, v_s'] = 0 \tag{1.12}$$

Specifically, a *state space* model for an $n-$dimensional time series (in our case ΔR_t) consists of a measurement equation (1.10) relating the observed data to an $m-$dimensional state vector (β_t), and a transition equation (1.11) describing the dynamics of the state vector over time. The transition equation, as shown above, takes the form of a first-order difference equation in the state vector. The X_{t-1} vector contains the four right-hand-side variables from equation (1.6). Equations (1.12) define the errors as *iid* and assumes that the measurement equation errors are independent of the transition equation errors for all $s=t$.

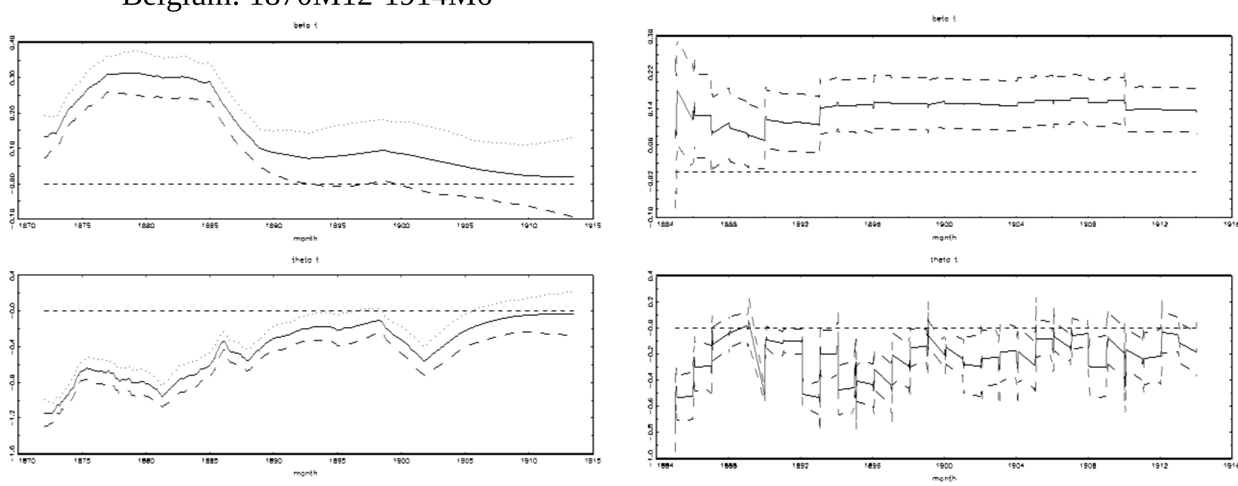
The *Kalman filter* is the tool that deals with state space models. A Kalman filter basically uses a recursive procedure for computing the optimal estimates of the state vector (β_t), using all available information up to time t. The filter consists of two sets of equations as described in Kim and Nelson (1998). The first is the *prediction equations* at the beginning of time t which are used to predict an optimal estimate of the $n-$dimensional time series (ΔR_t) defined above using all available information up to time $t-1$, $\Delta R_{t|t-1}$. This requires the estimation of the state vector (β_t) using information up to $t-1$, $\beta_{t|t-1}$. In the second step, once (ΔR_t) is realized at the end of time t, we can form a more accurate inference about our state vector, $\beta_{t|t}$, through a set of *updating equations* after calculating a prediction error. Specifically, $\beta_{t|t}$ is now our updated estimate of β_t based on the appropriate weights assigned to the new information, contained in the prediction error, up to time t. These weights, or the Kalman gain, are a function of the prediction error variance due to uncertainty in $\beta_{t|t-1}$ and shocks to the measurement equation error, e_t.

Results are presented in Figures (1.1) through (1.3), each representing one of our three time periods under investigation.[12] The figures contain two panels for every country reported. The first panel is the estimated time-varying short-run regression coefficient, $\hat{\beta}_t$, on the changes in a country's base rate, while the second panel represents the estimate of the time-varying $\hat{\theta}_t$ coefficient on the lagged error correction term.[13]

Results are informative and reveal rather interesting patterns. Some general observations are in order. The first is that the short-run regression coefficient, $\hat{\beta}_t$, and the lagged error correction coefficient, $\hat{\theta}_t$, generally move opposite to each other, as one would expect following the hypothesis of macroeconomic policy trilemma. Periods of high or increasing $\hat{\beta}_t$'s are accompanied by low or decreasing $\hat{\theta}_t$'s, and vice versa. A second observation is that periods of non-pegged exchange rates mostly show higher volatility than periods with pegged exchange rates.

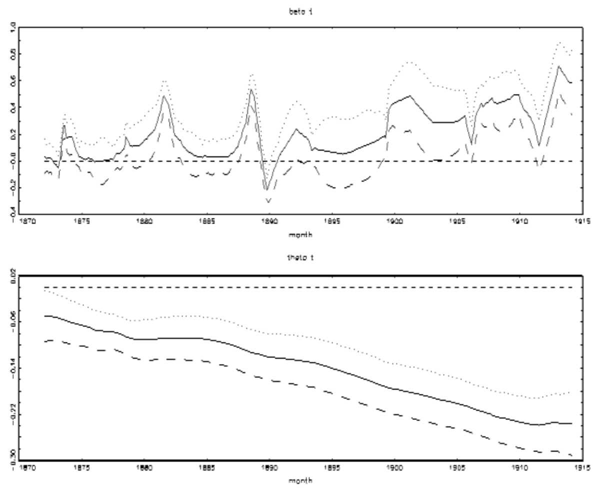
Figure 1.1: Time-Varying Parameters in the Gold Standard Era

Belgium: 1870M12-1914M6 | Denmark: 1884M5-1914M6

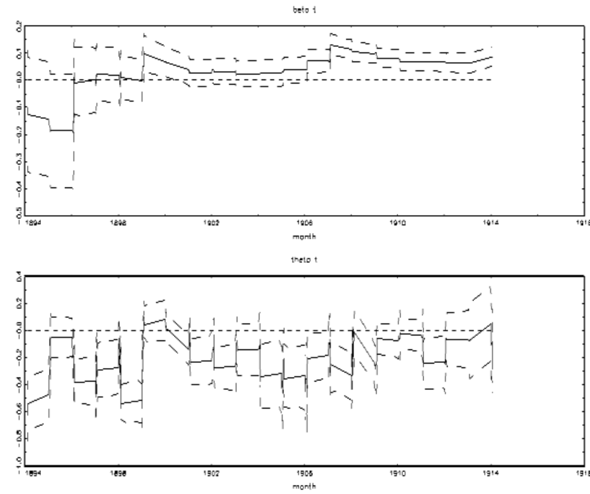


[12] Results are obtained by modifying GAUSS codes available from Kim and Nelson (1998).
[13] Results of the other time-varying coefficients, $\hat{\alpha}_t$ and $\hat{\mu}_t$, are not reported for space considerations.

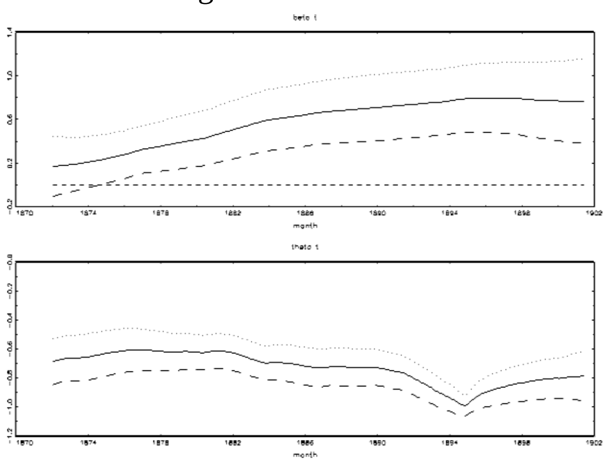
France: 1872M4-1914M6



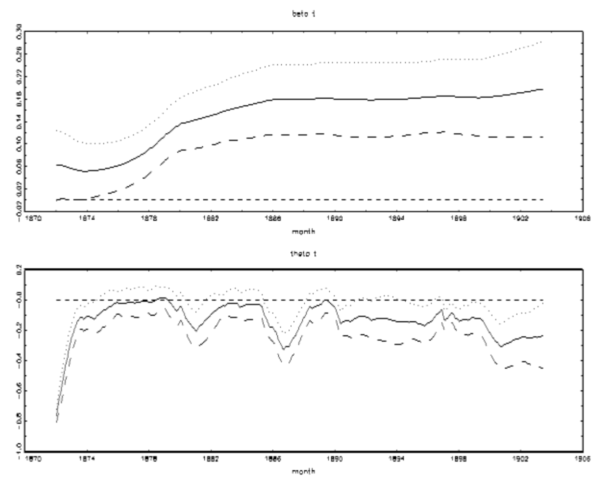
Norway: 1894M1-1914M6



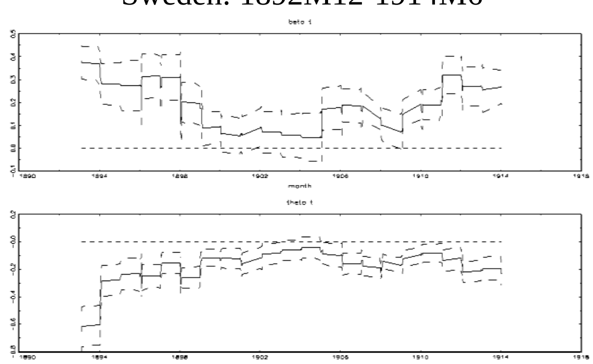
Portugal: 1885M1-1914M6



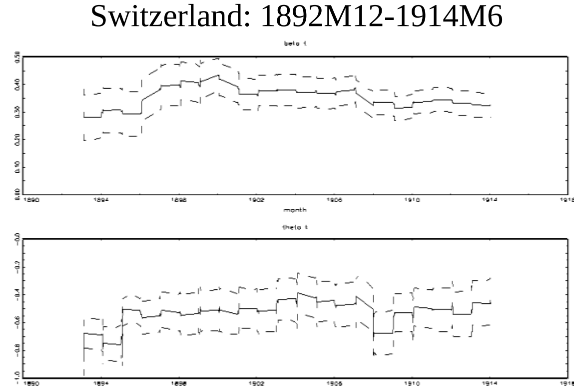
Spain: 1883M1-1914M6



Sweden: 1892M12-1914M6



Switzerland: 1892M12-1914M6



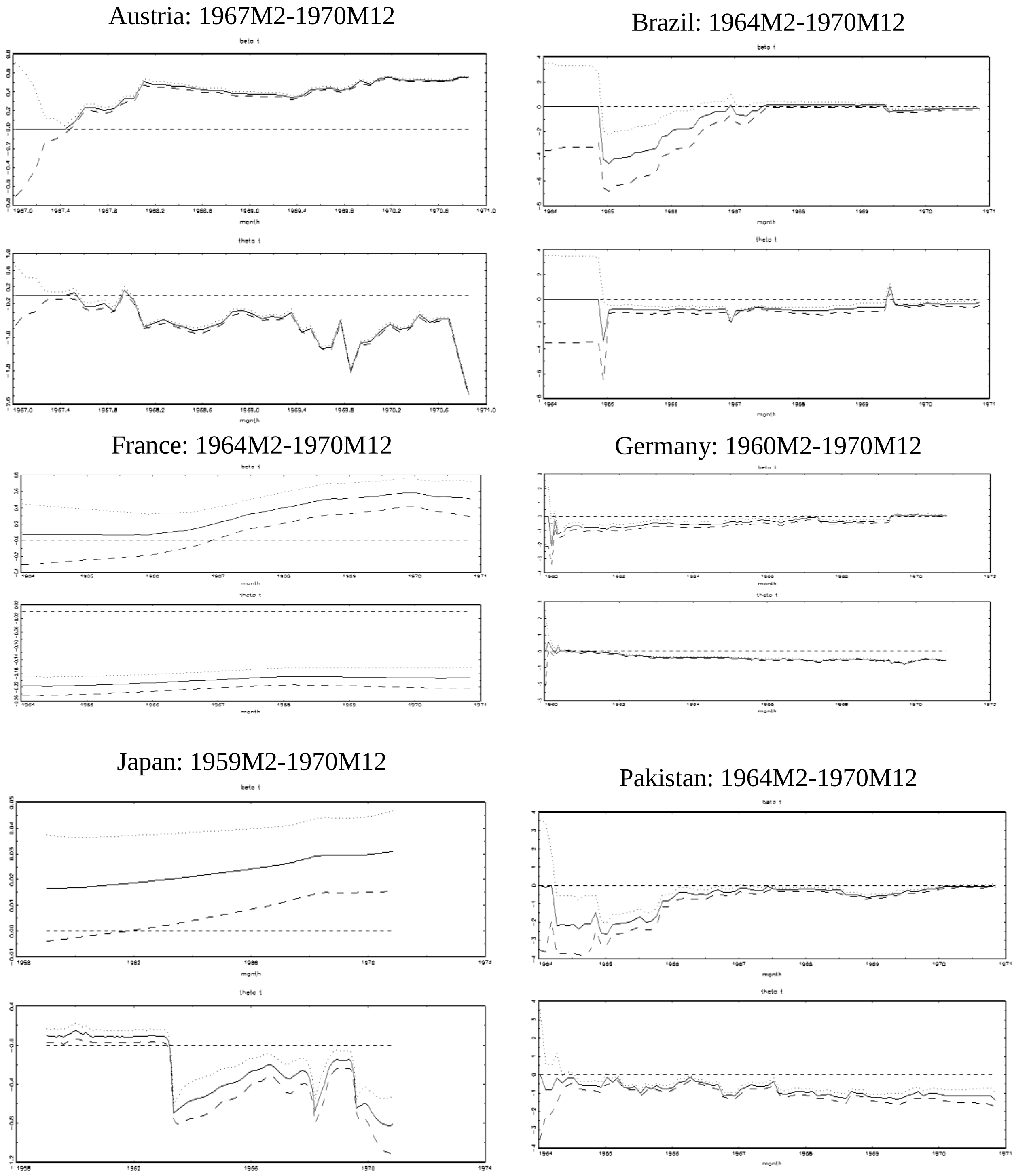
For the ***gold standard era***, one can see that non-pegged periods are indeed more volatile than pegged periods. This is evident from the frequent volatility in the reported $\hat{\beta}_t$ and $\hat{\theta}_t$ coefficients during non-pegged periods. France and Norway, on the other hand, have experienced decreasing monetary independence over time. This is shown from the fact that the short-run regression coefficient, $\hat{\beta}_t$, and the (absolute value) of the lagged error correction coefficient, $\hat{\theta}_t$, are both increasing over time indicating lower monetary independence and a faster speed of adjustment (shorter half-life). This result is supported by the data. In the case of France, we can notice that the French Franc has been weakly pegged to the Sterling pound in the early years of the gold standard era, with the peg gaining strength as we move to the end of the period. This fact becomes more evident if we redefine a pegged exchange rate in the de facto classification as one staying within a ±0.5% band instead of a ±2% band against the Sterling pound over a whole year. Under this strict definition, it is apparent that France has experienced a number of non-pegged periods early in time during the gold standard era, slowly moving to complete pegs over time towards the end of the era. Such an observation has also been noted by Tullio and Wolters (2004), where they show that the Bank of France kept their interest rate unchanged at 3% for 5 years at the beginning of the gold standard era from 1883 to 1888, despite the fact that the Bank of England changed their interest rate 35 times during the same period.

Using the same de facto definition, one can also explain why Belgium has experienced increasing monetary independence over the course of the gold standard era. As can be seen from the graphs, Belgium clearly witnessed a decreasing $\hat{\beta}_t$ coefficient and an increasing $\hat{\theta}_t$ coefficient over time. A similar observation has been made by Morys (2011), where he estimated central bank reaction functions for a number of countries during the Gold Standard era. Using a probit model, his findings suggest that in the case of Belgium there have been many other factors determining its interest rate setting behavior other than following the interest rate set by the Bank of England.

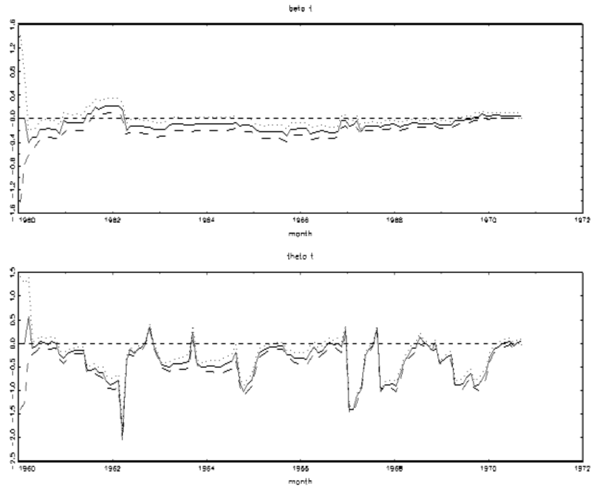
Portugal and Spain show the predicted movements in the $\hat{\beta}_t$ and $\hat{\theta}_t$ coefficients as they switch from peg to non-peg to peg over the course of the gold standard era. During the initial peg (1883M1-1891M7), one can notice the increasing $\hat{\beta}_t$ coefficients, they then flatten as the countries go through their non-peg period (1891M8-1901M11), and pick up once again during their late peg period (1910M6-1914M6). Finally, a few countries show no clear pattern over the course of the gold standard era. These are Denmark, Germany (except for spark in 1905), Netherlands, Sweden, Switzerland and the United States.

We now consider results from the ***Bretton Woods period*** (see Figure (1.2)) characterized by closed capital markets and (mostly) pegged exchange rate regimes. Generally, countries or periods of pegged exchange rates show less monetary independence, or at $\hat{\beta}_t$ coefficients above the zero dashed line in the graphs of Figure (1.2). Our single country with a non-pegged exchange rate throughout the entire Bretton Woods period, Brazil, shows considerable monetary policy autonomy. The short-run $\hat{\beta}_t$ coefficient is either negative or very close to zero implying no relationship with the local and base country interest rates.

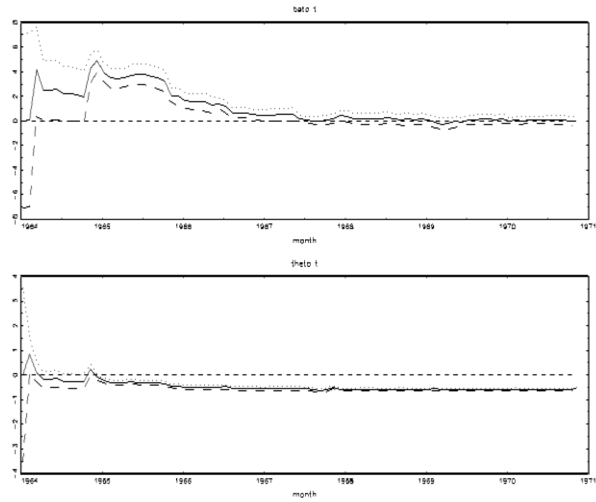
Figure 1.2: Time-Varying Parameters in the Bretton Woods Era



Sweden: 1960M4-1970M12



United Kingdom: 1964M2-1970M12



Again, non-pegged periods seem to exhibit more volatility in the time-varying parameters reported. This is clear in the case of Germany (1969M6-1970M12). Other countries, for example France, show the expected trends as the country switches from a peg to non-peg at the very end of the period. Specifically, the short-run regression $\hat{\beta}_t$ coefficient has been increasing steadily during the peg period (1964M1-1968M12) indicating low monetary independence, but dropped near the end of the period (1969M1-1970M12) indicating more independence from the base country interest rate.

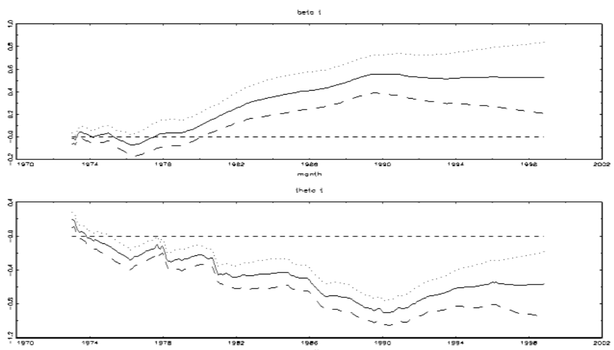
Austria and Japan are two countries that have experienced decreasing monetary independence over time, as seen from their steadily increasing short-run regression $\hat{\beta}_t$ coefficients. Although both countries pegged their exchange rates to the U.S. dollar over the entire Bretton Woods period, these pegs became stronger over time. This is clearly seen when we strict our definition of a pegged exchange rate as one staying within a ±0.5% band instead of a ±2% band against the U.S. dollar over a whole year. These recalculations show that Austria and Japan have indeed witnessed some weak pegging during the beginning of the period, turning to a stronger peg as we move towards the end of the Bretton Woods era. In the case of Japan, fixing the yen-dollar exchange rate served the country's trade balance well as Japanese inflation did not increase in line with that of the U.S. towards the end of the Bretton Woods period (see Hetzel 1999). This lead to an undervaluation of the Japanese yen, helping Japan's exports and explaining why Japan favored pegging its exchange rate to that of the U.S. during that period.

The exact opposite is true for Germany, Pakistan and the United Kingdom. These countries have experienced increasing monetary independence over time as evident by their decreasing short-run regression $\hat{\beta}_t$ coefficients over time closely approaching zero at the end of the period. Indeed, we can see that these countries' exchange rates have been witnessing weaker pegs (non-pegs if we apply the strict ±0.5% band) over time towards the end of the Bretton Woods period. In the case of Germany, as argued by Hetzel (2002), it could not maintain its peg with the dollar as this required it to match the increasing inflation rates in the U.S. in the second half of the 1960's. During that period, the U.S. adopted inflationary monetary policies that eventually lead to the destruction of the Bretton Woods system in 1971. Regarding the United Kingdom, its steady departure from the peg with U.S. dollar was driven by different reasons. As argued by Bordo (1993), the United Kingdom's problem was a slower growth rate than that of its trading partners along with higher inflation, ultimately threatening the competitiveness of the Sterling pound. This eventually forced a discretionary devaluation of the Sterling pound in 1967, thus moving away from the dollar peg towards the end of the Bretton Woods period. Other countries in our sample during this period have shown no clear pattern over time. It seems that the capital controls applied by these countries have completely blocked any effect an exchange peg can have on monetary policy.

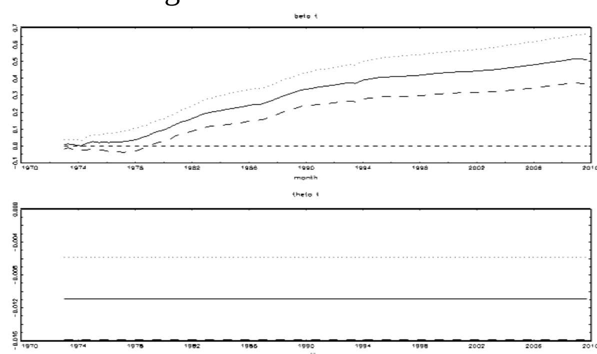
Figure (1.3) reports results from the ***post-Bretton Woods era***. Due to the large number of countries in this period, we only report the major findings.

Figure 1.3: Time-Varying Parameters in the Post-Bretton Woods Era

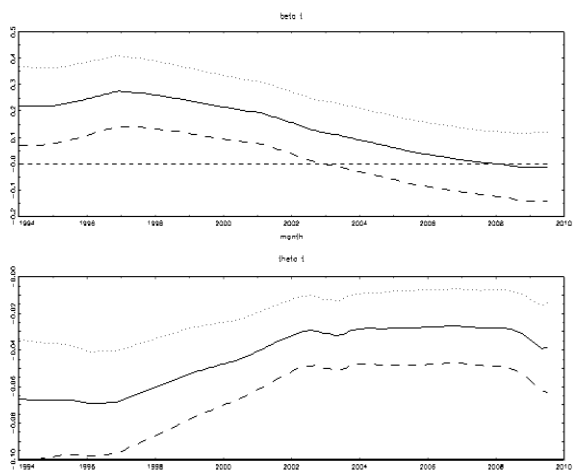
Austria: 1973M2-1998M12



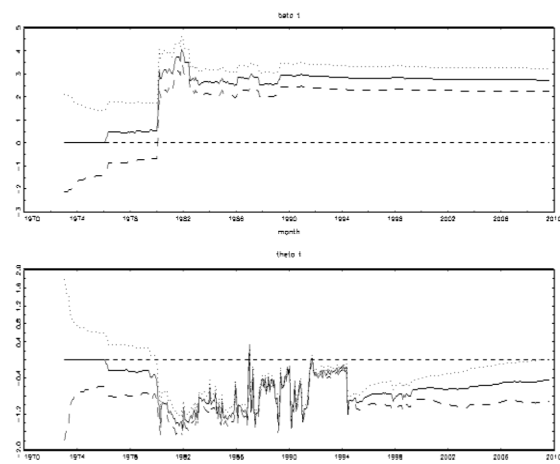
Belgium: 1973M2-2009M11



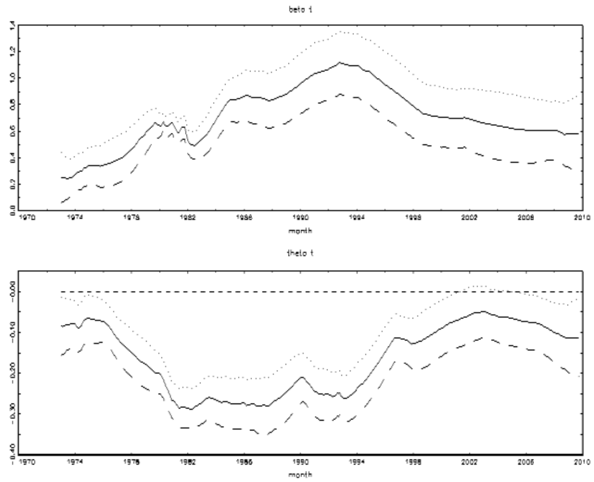
Bolivia: 1994M2-2009M8



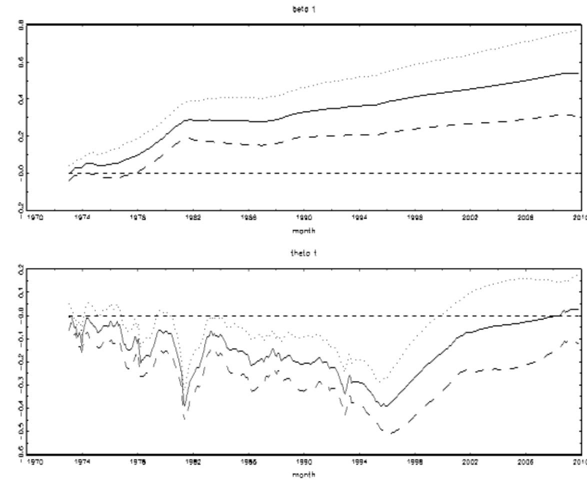
Brazil: 1973M2-2009M10



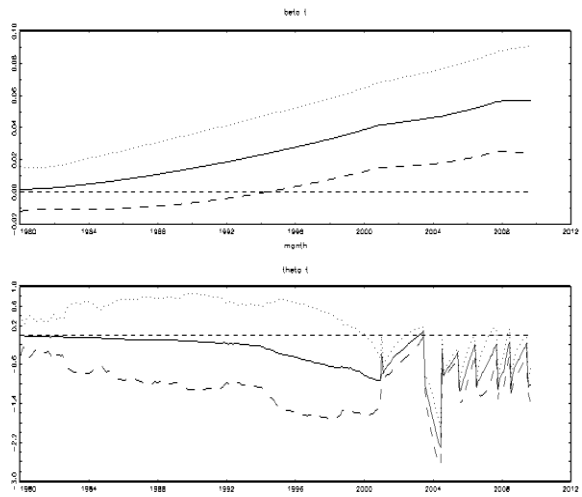
Canada: 1973M2-2009M11



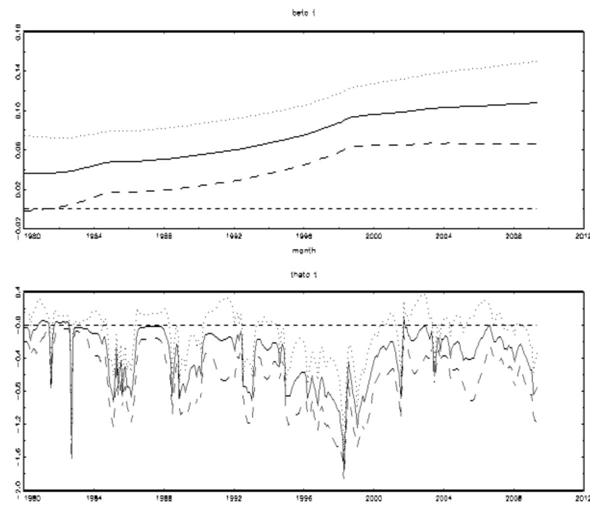
France: 1973M2-2009M12



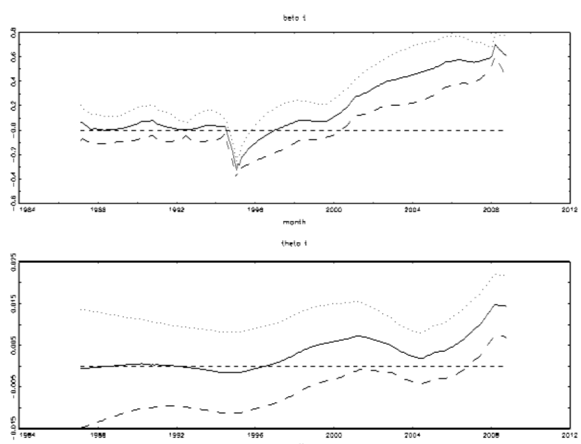
Grenada: 1980M2-2009M10



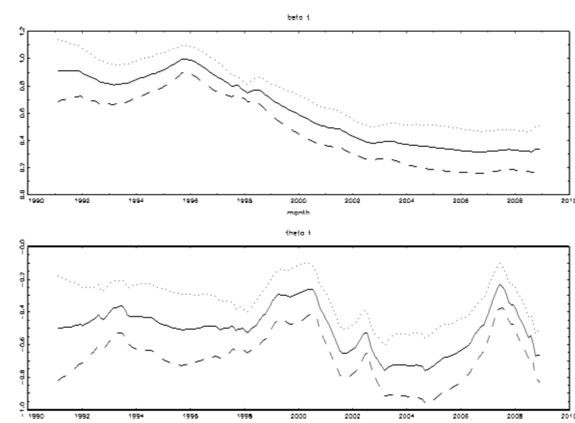
Lesotho: 1980M4-2009M10



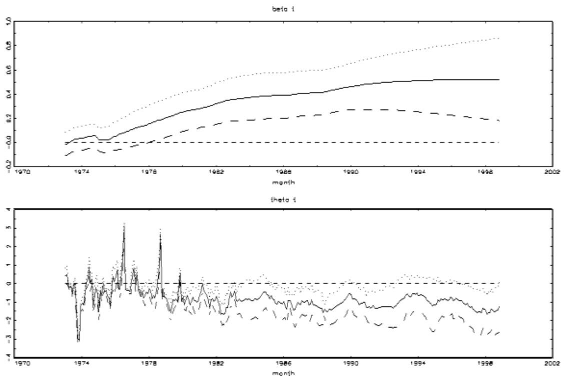
Malta: 1987M12-2009M8



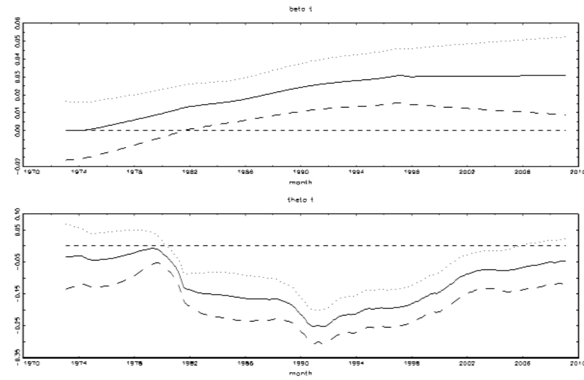
Namibia: 1991M1-2009M8



Netherlands: 1973M2-1998M12



Singapore: 1973M5-2009M6



Once again, non-pegged countries or periods exhibit, on average, higher volatility in their conduct of monetary policy as illustrated by the frequent movements of a the short-run regression $\hat{\beta}_t$ lagged error correction $\hat{\theta}_t$ coefficients over time.[14] It is also worth noting that Benin, Burkina Faso, Cote D'Ivoire, Mali and Senegal all displayed the same spark in the 1992-1994 period.[15] These countries are all part of the West African Monetary Union and they peg their currency to the French Franc. In January 1994, member countries of the union sharply devalued their currency in an attempt to help the union's export sectors. This was reflected in the conduct of the union's monetary policy leading to the spark.

Some countries have experienced decreasing monetary independence over the course of the post-Bretton Woods period, as evident by the steady rise in the short-run $\hat{\beta}_t$ coefficient and corresponding decline in the $\hat{\theta}_t$ coefficient over time. An example is Grenada. On the other hand, some countries experienced increasing monetary autonomy

[14] Examples include the non-peg periods of Brazil (1973M1-2009M10), Israel (1984M6-2009M3), Italy (1973M1-2009M11), Kuwait's early non-peg (1979M1-1993M1), Malaysia's early non-peg (1973M1-1999M9), Spain (1974M1-1995M12), Sri Lanka (1978M1-2008M12) and Sweden (1973M1-2009M4). These results are not shown for space considerations.

[15] Results are not shown for space considerations but are available upon request.

over time as they witnessed a decreasing $\hat{\beta}_t$ and increasing $\hat{\theta}_t$ coefficient over time. Recall our definition of an exchange rate peg as staying within a ±2% band against the base country exchange rate over twelve months. Looking at Bolivia, one can notice that its exchange rate was within a ±2% to ±4% range at the beginning of the period, but then the non-peg moved further away from the border line of our definition into the ±6% to ±8% range. This increase in the flexibility of the exchange rate may help explain the growing monetary independence over time, as the country's local interest rate has been moving further and further away from the base rate.

The time-varying parameter methodology also captures the effects of changes in exchange rate regimes and capital controls on the autonomy of domestic monetary policy over time. Austria's initial non-peg (1973M1-1975M5) and closed capital market policies are accompanied by near zero $\hat{\beta}_t$ and $\hat{\theta}_t$ coefficients. However, once the country switched to a pegged exchange rate in 1975M6, the short-run $\hat{\beta}_t$ coefficient starts to pick up gradually and rises even more as the country opens its capital markets near the end of the period. These movements in the $\hat{\beta}_t$ coefficient are accompanied by a movement of the $\hat{\theta}_t$ coefficient in the opposite direction, as the trilemma predicts. A very similar pattern is found in the case of France. France's initial non-peg (1973M1-1983M1) and closed capital market (1973-1989) was a period of near zero $\hat{\beta}_t$ and $\hat{\theta}$ coefficients. But as soon as France switched to a pegged exchange rate regime (1983M2-2009M12) and an open capital market (1990-2009), the short-run $\hat{\beta}_t$ coefficient started rising, and the lagged error correction $\hat{\theta}_t$ coefficient started declining. Canada's monetary dependence reached its maximum in 1994 as illustrated by the peak in the short-run $\hat{\beta}_t$ coefficient and trough in the $\hat{\theta}_t$ coefficient. This can be explained by the fact that Canada fixed its exchange rate against the U.S. dollar during the period (1990M2-1997M2) along with open capital markets. The steady decline (rise) that we observe in the $\hat{\beta}_t$ coefficient ($\hat{\theta}_t$ coefficient) following that period is a consequence of the abolishment of this peg (the 1997M3-2009M11 non-peg). The same analysis applies to Namibia with monetary dependence reaching the peak in 1992 which can be explained by the fact that Namibia fixed its exchange rate during 1991M9-1992M9, and then liberalized it afterwards (1992M9-2009M8) which is when we start observing the steady decline (rise) in the $\hat{\beta}_t$ coefficient ($\hat{\theta}_t$ coefficient).

Changing capital control conditions also seem to have significant impact on the conduct and autonomy of monetary policy, putting the effect of exchange rate regime aside. Malta, for example, has had a flexible exchange rate system throughout the whole period, but it removed capital restrictions in 2002. Looking at Figure (1.3), we can see that Malta's initial closed capital market period (1987-2001) witnessed a near zero $\hat{\beta}_t$ coefficient, but a steadily rising coefficient starting 2002 till the end of the period. Netherlands fixed its exchange rate throughout the whole period (1973M1-1998M12), but only opened its capital markets from 1975-1998 after restricting international capital transactions for 1973-1974. This information is accurately reflected in the time-varying coefficients of Netherlands where the short-run $\hat{\beta}_t$ coefficient started picking up only after 1975.

Belgium's coefficients over time clearly show that the country had experienced "fear of floating". During the country's initial peg (1973M1-1981M1) with an open capital market, we can see that the short-run $\hat{\beta}_t$ coefficient was steadily increasing, but continued to rise even after the country liberated its exchange rate (1982M2-2009M11). A similar pattern is seen for Lesotho during its initial peg (1980M3-1995M9) and non-peg (1995M10-2009M10) afterwards, as well as Singapore's non-peg (1984M2-1994M1) period that continued to witness monetary policy dependence.

Overall, results from the time-varying parameter methodology have improved our insight and understanding of the dynamics of the macroeconomic policy trilemma over time. Findings for most countries are rather informative using the time-varying approach as explained above. For a number of other countries, however, there has been no significant time variation in the short-run $\hat{\beta}_t$ and lagged error correction $\hat{\theta}_t$ coefficients, so we do not report graphs for these countries. Since the biggest majority of these countries are ones which did not experience any changes in their exchange rate regimes and/or capital control statuses, it is not surprising that there has not been much variation in their coefficients over time.

1.4. Summary and Conclusion

Do exchange rate regimes and capital control conditions affect the autonomy of domestic monetary policy? Results from this paper suggest that the answer is "Yes". Our objective was to examine whether the exchange-rate and capital-control regimes influence the degree to which domestic interest rates follow the world (base country) interest rate. The macroeconomic policy trilemma seems to explain a great deal of the movements in local interest rates. We have examined the implications of the trilemma using an extended dataset of developing and developed countries that covers three different time periods, characterized by different exchange rate regimes and capital flow restrictions allowing significant within and across era comparisons.

Based on first-difference regressions and cointegration analysis, our findings suggest that, on average, pegged exchange rates result in lower monetary independence compared to non-pegs as evident by the high magnitudes and significance of the first-difference or short-run regression coefficients and fast speeds of adjustment. This is especially true during the gold standard era because all countries in that period had perfectly open capital markets, while they were completely and partially closed during the Bretton Woods and post-Bretton Woods periods, respectively. Furthermore, the transmission of world interest rate changes to domestic rate changes was higher for countries/episodes with unrestricted capital markets than ones with controlled capital markets. We have also found evidence of "fear of floating", where countries are non-pegged de jure, but de facto follow their base country interest rate as indicated by stronger level relationships and faster speeds of adjustment. Overall, countries with pegged exchange rates and unrestricted international capital markets exhibit the lowest monetary independence of all. Giving up one or both policy options leads to higher independence.

Results from parameter instability tests reveal that the estimated coefficients using the fixed-coefficient bounds testing methodology suffer from structural breaks over the long periods of data that we use. This result motivates our application of a time-varying parameter methodology to better understand the dynamics of the trilemma over time. Results reveal considerable time variation in the reported coefficients. Non-pegged periods, on average, exhibit higher volatility in domestic interest rates compared to pegged periods. Some countries have experienced increasing monetary independence over time, others experienced decreasing independence. We have also been able to capture changes in monetary policy autonomy as countries switch between different exchange rate regimes and/or capital control restrictions over time allowing a more accurate test of the macroeconomic policy trilemma.

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Table 1.4: Appendix Table A1: Gold Standard Data

Country	*Exchange Rate*			*Capital Controls*
	De Jure Classification	*De Facto Classification*	*Base Country*	
Austria	Non-peg: 1871M2-1892M7, Peg: 1893M9-1914M6	Peg: 1879M6-1888M8, Peg: 1894M5-1914M6	U.K.	Open
Belgium	Peg: 1870M1-1914M6	Peg: 1872M12-1914M6	U.K.	Open
Denmark	Peg: 1884M5-1914M6	Peg: 1884M5-1914M6	U.K.	Open
France	Peg: 1872M4-1914M6	Peg: 1872M4-1914M6	U.K.	Open
Germany	Peg: 1872M12-1914M6	Peg: 1872M7-1914M6	U.K.	Open
India	Non-peg: 1884M5-1897M12, Peg: 1899M1-1914M6	Non-peg 1890M10-1897M12, Peg: 1899M1-1914M6	U.K.	Open
Italy	Peg: 1885M1-1893M12, Non-peg: 1894M1-1914M6	Peg: 1885M1-1892M2, Peg: 1902M10-1914M6	U.K.	Open
Netherlands	Non-peg: 1871M3-1875M5, Peg: 1876M6-1914M6	Peg: 1870M1-1914M6	U.K.	Open
Norway	Peg: 1894M1-1914M6	Peg: 1894M1-1914M6	U.K.	Open
Portugal	Peg: 1885M1-1891M6, Non-peg: 1891M7-1914M6	Peg: 1885M1-1891M7, Non-peg: 1891M8-1901M11, Peg: 1910M6-1914M6	U.K.	Open
Russia	Non-peg: 1871M2-1896M12, Peg: 1897M1-1900M8	Non-peg: 1875M12-1882M2, Non-peg: 1887M11-1893M9, Peg: 1894M6-1900M8	U.K.	Open

Country	Exchange Rate			Capital Controls
	De Jure Classification	*De Facto Classification*	*Base Country*	
Spain	Non-peg: 1883M1-1914M6	Peg: 1883M1-1891M7, Non-peg: 1891M8-1901M11, Peg: 1910M6-1914M6	U.K.	Open
Sweden	Peg: 1892M12-1914M6	Peg: 1892M12-1914M6	U.K.	Open
Switzerland	Peg: 1892M12-1914M6	Peg: 1892M12-1914M6	U.K.	Open
United States	Peg: 1880M11-1914M6	Peg: 1883M1-1914M6	U.K.	Open

Table 1.5: Appendix Table A2: Bretton Woods Data

Country	*Interest rate*	*Exchange Rate*		*Capital Controls*
		ERR	*Base country*	
Austria	Money market	Peg: 1967M1-1970M12	U.S.A.	Closed
Barbados	Treasury Bill	Non-peg: 1967M1-1967M12, Peg: 1968M1-1970M12	U.S.A.	Closed
Belgium	Treasury Bill	Peg: 1959M1-1970M12	U.S.A.	Closed
Brazil	Money market	Non-peg: 1964M1-1970M12	U.S.A.	Closed
Canada	Treasury Bill	Peg: 1959M1-1959M12, Non-peg: 1960M1-1961M12, Peg: 1962M1-1969M12,	U.S.A.	Closed

Country	*Interest rate*	*Exchange Rate*		*Capital Controls*
		ERR	*Base country*	
		Non-peg: 1970M1-1970M12		
France	Money market	Peg: 1964M1-1968M12, Non-peg: 1969M1-1970M12	U.S.A.	Closed
Germany	Money market	Peg: 1960M1-1969M5, Non-peg: 1969M6-1970M12	U.S.A.	Closed
India	Money market	Peg: 1959M1-1970M12	U.S.A.	Closed
Jamaica	Treasury Bill	Peg: 1961M5-1970M12	U.S.A.	Closed
Japan	Treasury Bill	Peg: 1959M1-1970M12	U.S.A.	Closed
Netherlands	Money market	Peg: 1960M1-1970M12	U.S.A.	Closed
Pakistan	Money market	Peg: 1964M1-1970M12	U.S.A.	Closed
South Africa	Treasury Bill	Peg: 1959M1-1970M12	U.S.A.	Closed
Sweden	Treasury Bill	Peg: 1960M3-1970M12	U.S.A.	Closed
Trinidad and Tobago	Treasury Bill	Peg: 1964M12-1966M12, Non-peg: 1967M1-1967M12, Peg: 1968M1-1970M12	U.S.A.	Closed
United Kingdom	Treasury Bill	Peg: 1964M12-1966M12, Peg: 1968M1-1970M12	U.S.A.	Closed

Table 1.6: Appendix Table A3: Post-Bretton Woods Data

Country	*Interest rate*	*Exchange Rate*		*Capital Controls*
		ERR	*Base country*	
Algeria	Treasury bill	Non-peg: 1980M1-2009M11	France	Closed
Antigua and Barbuda	Treasury bill	Peg: 1980M1-2009M10	U.S.A.	Open
Argentina	Money market	Non-peg: 1979M3-1991M3, Peg: 1992M4-2003M4, Non-peg: 2003M5-2009M11	U.S.A.	Closed 1979-1992, Open 1993-2004, Closed 2005-2009
Australia	Money market	Non-peg: 1973M1-2009M11	U.S.A.	Closed 1973-1983, Open 1984-2009
Austria	Money market	Non-peg: 1973M1-1975M5, Peg: 1975M6-1998M11	Germany	Closed 1973-1990, Open 1991-1998
Bahamas, The	Treasury bill	Peg: 1973M1-2009M11	U.S.A.	Closed
Bahrain, Kingdom of	Treasury bill	Peg: 1987M6-2009M10	U.S.A.	Open
Belgium	Treasury bill	Peg: 1973M1-1981M1, Non-peg: 1982M2-2009M11	Germany	Open
Belize	Treasury bill	Peg: 1978M12-2009M10	U.S.A.	Closed 1978-1985, Open 1986-1999, Closed 2000-2009
Benin	Money market	Peg: 1975M7-2009M10	France	Closed
Bolivia	Treasury bill	Non-peg: 1994M1-2009M8	U.S.A.	Open
Brazil	Money market	Non-peg: 1973M1-2009M10	U.S.A.	Closed
Burkina Faso	Money market	Peg: 1975M7-2009M10	France	Closed
Canada	Treasury bill	Non-peg: 1973M1-1990M1, Peg: 1990M2-1997M2, Non-peg: 1997M3-2009M11	U.S.A.	Open
China, P.R.	Treasury bill	Peg: 1993M12-2009M11	U.S.A.	Closed
Colombia	Money market	Non-peg: 1995M3-2009M11	U.S.A.	Closed
Côte d'Ivoire	Money market	Peg: 1975M7-2009M10	France	Closed
Denmark	Money market	Non-peg: 1973M1-2009M11	Germany	Closed 1973-1987, Open 1988-2009
Dominica	Treasury bill	Peg: 1980M1-2009M9	U.S.A.	Closed

Country	Interest rate	Exchange Rate		Capital Controls
		ERR	Base country	
Dominican Republic	Money market	Peg: 1996M2-2001M6, Non-peg: 2001M7-2009M12	U.S.A.	Closed
Egypt	Treasury bill	Peg: 1997M2-2000M7, Non-peg: 2000M8-2004M5, Peg: 2004M6-2009M10	U.S.A.	Closed 1997-1999, Open 2000-2009
El Salvador	Money market	Peg: 1997M2-2006M6	U.S.A.	Open
Ethiopia	Treasury bill	Peg: 1985M6-1993M12 Non-peg: 1994M1-2002M3, Peg: 2002M4-2007M4, Non-peg: 2007M5-2009M1	U.S.A.	Closed
Fiji	Treasury bill	Non-peg: 1975M1-2009M7	U.S.A.	Closed
Finland	Money market	Non-peg: 1977M12-2009M12	Germany	Closed 1977-1990, Open 1991-2009
France	Treasury bill	Non-peg: 1973M1-1983M1, Peg: 1983M2-2009M12	Germany	Closed 1973-1989, Open 1990-2009
Germany	Money market	Non-peg: 1973M1-2009M12	U.S.A.	Open
Ghana	Treasury bill	Peg: 1978M1-1983M8, Non-peg: 1983M9-2004M12, Peg: 2005M1-2009M4	U.S.A.	Closed
Grenada	Treasury bill	Peg: 1980M1-2009M10	U.S.A.	Closed
Guatemala	Money market	Non-peg: 1997M2-2000M7, Peg: 2000M8-2006M5	U.S.A.	Open
Indonesia	Money market	Non-peg: 1983M1-2009M11	U.S.A.	Open 1983-1999, Closed 2000-2009
Israel	Treasury bill	Non-peg: 1984M6-2009M3	U.S.A.	Closed 1984-2000, Open 2001-2009
Italy	Money market	Non-peg: 1973M1-2009M11	Germany	Closed 1973-1989, Open 1990-2009
Jamaica	Treasury bill	Peg: 1973M1-1983M10, Non-peg: 1983M11-2009M11	U.S.A.	Closed
Japan	Treasury bill	Non-peg: 1973M1-2009M11	U.S.A.	Closed 1973-1978,

Country	*Interest rate*	*Exchange Rate*		*Capital Controls*
		ERR	*Base country*	
				Open 1979-2009
Kenya	Treasury bill	Non-peg: 1973M1-2001M6, Peg: 2001M7-2004M1, Non-peg: 2004M2-2009M8	U.S.A.	Closed
Korea, Republic of	Money market	Non-peg: 1976M5-2009M10	U.S.A.	Closed 1976-2005, Open 2006-2009
Kuwait	Money market	Non-peg: 1979M1-1993M1, Peg: 1993M2-2007M7, Non-peg: 2007M8-2009M10	U.S.A.	Open
Lao People's Dem. Rep.	Treasury bill	Non-peg: 1994M12-2009M10	U.S.A.	Closed
Lebanon	Treasury bill	Non-peg: 19821M1-1994M1, Peg: 1994M2-2009M10	U.S.A.	Open 1994-1999, Closed 2000-2009
Lesotho	Treasury bill	Peg: 1980M3-1995M9, Non-peg: 1995M10-2009M10	South Africa	Closed
Luxembourg	Money market	Peg: 1990M1-1994M4	Belgium	Open
Madagascar	Money market	Non-peg: 1990M12-2009M7	France	Closed
Malawi	Treasury bill	Non-peg: 1983M1-2009M10	U.S.A.	Closed
Malaysia	Money market	Non-peg: 1973M1-1999M9, Peg: 1999M10-2006M1, Non-peg: 2006M2-2009M6	U.S.A.	Open 1973-1997, Closed 1998-2009
Mali	Money market	Peg: 1975M7-1995M1, Non-peg: 1995M2-2009M10	France	Closed
Malta	Treasury bill	Non-peg: 1987M11-2009M8	France	Closed 1987-2002, Open 2003-2009
Mauritius	Money market	Non-peg: 1979M1-2009M10	U.K.	Closed 1979-2001, Open 2002-2009
Mexico	Treasury bill	Non-peg: 1978M1-1991M1, Peg: 1991M2-2009M11	U.S.A.	Open 1978-1981, Closed 1982-2009
Morocco	Money market	Non-peg: 1980M12-2009M9	France	Closed
Mozambique	Money market	Non-peg: 1998M1-2009M8	U.S.A.	Closed
Namibia	Treasury bill	Peg: 1991M9-1992M9,	South Africa	Closed

Country	Interest rate	Exchange Rate		Capital Controls
		ERR	Base country	
Nepal	Treasury bill	Non-peg: 1992M10-2009M8 Peg: 1981M1-2009M6	U.S.A.	Closed
Netherlands	Money market	Peg: 1973M1-1998M12	Germany	Closed 1973-1974, Open 1975-1998
Netherlands Antilles	Treasury bill	Peg: 1982M1-2009M9	U.S.A.	Closed
New Zealand	Treasury bill	Non-peg: 1978M1-2009M11	Australia	Closed 1978-1983, Open 1984-2009
Niger	Money market	Peg: 1975M7-2009M10	France	Closed 1975-1994, Open 1995-1999, Closed 2000-2009
Nigeria	Treasury bill	Non-peg: 1991M7-2009M6	U.S.A.	Closed
Norway	Money market	Non-peg: 1973M1-2009M9	Germany	Closed 1973-1994, Open 1995-2009
Pakistan	Money market	Peg: 1973M1-1981M1, Non-peg: 1981M2-2009M11	U.S.A.	Closed
Paraguay	Money market	Peg: 1990M10-1999M1, Non-peg: 1999M2-2009M10	U.S.A.	Closed 1990-1999, Open 2000-2009
Philippines	Treasury bill	Non-peg: 1976M1-2009M10	U.S.A.	Closed
Poland	Money market	Non-peg:1990M12-2009M11	Germany	Closed
Portugal	Money market	Non-peg: 1983M1-1995M1, Peg: 1995M2-2000M3	Germany	Closed 1983-1992, Open 1993-2000
Romania	Money market	Non-peg: 1995M1-2009M10	U.S.A.	Closed 1995-2004, Open 2005-2009
Senegal	Money market	Peg: 1975M7-2009M10	France	Closed
Seychelles	Treasury bill	Non-peg: 1979M7-2004M3, Peg: 2004M4-2006M11, Non-peg: 2006M12-2009M10	U.S.A.	Open
Singapore	Treasury bill	Peg: 1973M4-1984M1, Non-peg: 1984M2-1994M1, Peg: 1994M2-2009M11	Malaysia	Closed 1973-1977, Open 1978-2009
South Africa	Treasury bill	Non-peg: 1973M1-2009M11	U.S.A.	Closed

Country	*Interest rate*	*Exchange Rate*		*Capital Controls*
		ERR	***Base country***	
Spain	Money market	Non-peg: 1974M1-1995M12, Peg: 1996M1-2009M11	Germany	Closed 1973-1993, Open 1994-2006, Closed 2007-2009
Sri Lanka	Money market	Non-peg: 1978M1-2008M12	U.S.A.	Closed
St. Kitts and Nevis	Treasury bill	Peg: 1980M1-2009M9	U.S.A.	Closed
St. Lucia	Treasury bill	Peg: 1980M1-2009M9	U.S.A.	Closed
St. Vincent & Grens.	Treasury bill	Peg: 1980M1-2009M11	U.S.A.	Closed
Swaziland	Treasury bill	Peg: 1981M12-2009M9	South Africa	Closed
Sweden	Treasury bill	Non-peg: 1973M1-2009M4	Germany	Closed 1973-1992, Open 1993-2006, Closed 2007-2009
Switzerland	Money market	Non-peg: 1975M9-2009M10	Germany	Closed 1973-1989, Open 1990-2006, Closed 2007-2009
Tanzania	Treasury bill	Non-peg: 1993M12-2009M10	U.S.A.	Closed
Thailand	Money market	Peg: 1977M1-2000M3, Non-peg: 2000M4-2004M12, Peg: 2005M1-2009M11	U.S.A.	Closed
Togo	Money market	Peg: 1975M7-2009M10	France	Closed
Tunisia	Money market	Non-peg: 1984M1-2009M11	France	Closed
Turkey	Money market	Non-peg: 1986M4-2009M11	U.S.A.	Closed
Uganda	Treasury bill	Non-peg: 1980M1-2009M11	U.S.A.	Closed 1980-1996, Open 1997-2009
United Kingdom	Treasury bill	Non-peg: 1973M1-2009M11	Germany	Closed 1973-1978, Open 1979-2009
Uruguay	Money market	Non-peg: 1992M12-2009M8	U.S.A.	Closed 1992-1995, Open 1996-2009
Venezuela, Rep. Bol.	Money market	Non-peg: 1996M1-2006M3, Peg: 2006M4-2009M11	U.S.A.	Open 1996-2004, Closed 2005-2009
Zambia	Treasury bill	Non-peg: 1978M1-2009M8	U.S.A.	Closed 1978-1995, Open 1996-2009

Country	*Interest rate*	*Exchange Rate*		*Capital Controls*
		ERR	*Base country*	
Zimbabwe	Treasury bill	Non-peg: 1978M12-2007M12	U.S.A.	Closed

Table 1.7: Appendix Table A4: Individual Country ARDL Regressions

	No. of obs.	*γ*	*β*	*θ*	*Half life*	*F*	*Stability*	*Adj R^2*
				Gold Standard – De Jure Classification				
Austria	521	0.61**	0.019	-0.04***	16.98	8.79***	4.55	.03
Belgium	533	0.52***	0.26***	-0.12***	5.42	19.4***	48.21***	.18
Denmark	362	-0.63	0.24***	-0.06***	11.20	7.7***	14.53***	.12
France	507	0.61***	0.13***	-0.11***	5.95	16.8***	15.56***	.09
Germany	499	0.29	0.21***	-0.08***	8.31	10.2***	28.94***	.16
India	362	1.15**	0.11	-0.12***	5.42	13.56***	7.97**	.07
Italy	354	0.08*	0.002	-0.42***	1.27	108.51***	49.48***	.40
Netherlands	520	0.89***	0.08***	-0.07***	9.55	17.77***	12.29***	.07
Norway	246	0.44***	0.11***	-0.31***	1.87	44.5***	42.72***	.27
Portugal	354	0.18	0.24*	-0.04**	16.98	60.00***	54.59***	.08
Russia	355	0.16	-0.05	-0.16***	3.98	15.48***	5.25*	.08
Spain	378	0.65***	0.09**	-0.18***	3.49	34.3***	23.66***	.15
Sweden	259	0.79***	0.07***	-0.02***	34.31	16.5***	5.43*	.04
Switzerland	259	0.56***	0.32***	-0.33***	1.73	39.2***	12.48***	.34
U.S.A.	404	0.62***	0.53***	-0.35***	1.61	44.1***	41.03***	.21
Pegs (average)		0.40	0.23	-0.17	8.80	24.80	26.11	0.18
Occ. pegs (average)		0.51	0.07	-0.14	9.03	37.35	22.36	0.12
Non-pegs (average)		0.65	0.09	-0.18	3.49	34.30	23.66	0.15
				Gold Standard – De Facto Classification				

	No. of obs.	γ	β	θ	Half life	F	Stability	Adj R^2
Austria	421	0.72**	0.1	-0.05***	13.51	6.26***	12.26*	.03
Belgium	499	0.41**	0.19***	-0.09***	7.35	12.3***	29.02***	.14
Denmark	362	-0.63	0.24***	-0.06***	11.20	7.7***	14.53***	.12
France	507	0.61***	0.13***	-0.11***	5.95	16.8***	15.56***	.09
Germany	504	0.28	0.21***	-0.08***	8.31	10.6***	29.70***	.17
India	285	0.47	-0.04	-0.03**	22.76	3.29**	5.31*	.02
Italy	354	0.08*	0.002	-0.42***	1.27	108.51***	16.37***	.40
Netherlands	528	0.87***	0.11***	-0.09***	7.35	21.9***	18.64***	.10
Norway	246	0.44***	0.11***	-0.31***	1.87	44.5***	42.72***	.27
Portugal	354	0.18	0.24*	-0.04**	16.98	60.00***	54.59***	.08
Russia	297	0.40	-0.11	-0.14***	4.60	12.09***	6.01**	.08
Spain	378	0.65***	0.09**	-0.18***	3.49	34.3***	23.66***	.15
Sweden	259	0.79***	0.07***	-0.02***	34.31	16.5***	5.43*	.04
Switzerland	259	0.56***	0.32***	-0.33***	1.73	39.2***	12.48***	.34
U.S.A.	378	0.7***	0.57***	-0.35***	1.61	40.9***	32.75***	.21
Pegs (average)		0.47	0.18	-0.17	8.90	29.56	20.86	0.17
Occ. pegs (average)		0.16	0.08	-0.10	11.96	27.42	22.39	0.08
				Bretton Woods				
Austria	47	0.50	0.30*	-0.12	5.42	1.29	7.52**	.13
Barbados	47	0.58***	-0.07	-0.13*	4.98	3.13**	2.16	.09
Belgium	143	0.53***	0.04	-0.12***	5.42	5.62***	4.07**	.06
Brazil	83	0.70	-0.64	-0.04	16.98	1.30	3.58	.03
Canada	143	0.70***	0.59***	-0.12***	5.42	3.94**	2.71	.13
France	83	1.56***	0.44**	-0.13**	4.98	3.38**	3.01	.12
Germany	131	1.14***	-0.20	-0.14***	4.60	7.02***	12.25*	.09
India	143	0.28	-0.82**	-0.27***	2.20	12.29***	1.57	.15
Jamaica	115	-0.07	0.014	-0.03	22.76	1.08	2.79	.002
Japan	143	0.05	0.02	-0.02*	34.31	1.37	10.45***	.02
Netherlands	131	1.40***	0.43***	-0.14***	4.60	5.81***	2.74	.11

	No. of obs.	γ	β	θ	Half life	F	Stability	Adj R^2
Pakistan	83	-0.04	-0.15	-0.05*	13.51	1.48	1.53	.02
South Africa	143	0.44	-0.03	-0.013	52.97	0.47	4.45**	.001
Sweden	129	0.91***	0.007	-0.28***	2.11	11.31***	3.53	.14
Trinidad and Tobago	72	0.14	0.13	-0.12*	5.42	1.83	2.25	.05
United Kingdom	83	0.54***	0.29**	-0.14***	4.60	4.52**	9.11***	.13
Pegs (average)		0.57	0.06	-0.12	5.42	3.55	4.64	.08
Non-pegs (average)		0.70	-0.64	-0.04	16.98	1.30	3.58	.03
				Post-Bretton Woods				
Algeria	358	2.46	0.03	-0.004	172.94	1.36	12.59*	.002
Antigua & Barbuda	357	0.02	0.004	-0.12***	5.42	11.24***	6.47**	.05
Argentina	225	-0.77	-1.21	-0.35***	1.61	49.94***	48.95***	.31
Australia	442	1.15***	-0.03	-0.04***	16.98	9.37***	6.35**	.04
Austria	311	0.64***	0.067**	-0.05***	13.51	3.44**	14.15***	.02
Bahamas, The	442	0.76***	0.02	-0.06***	11.20	13.26***	6.10**	.05
Bahrain, Kingdom	268	1.05***	0.75***	-0.18***	3.49	15.40***	24.08***	.45
Belgium	442	1.70**	0.03*	-0.01***	68.97	1.87	21.04***	.007
Belize	370	1.02***	0.007	-0.03***	22.76	9.42***	2.58	.04
Benin	411	0.73***	0.30***	-0.07***	9.55	8.13***	13.12***	.09
Bolivia	187	4.81	0.06	-0.02**	34.31	3.21**	3.25	.02
Brazil	441	4.15	0.24	-0.05***	13.51	5.98***	2.24	.02
Burkina Faso	411	0.74***	0.31***	-0.11***	5.95	11.71***	16.30***	.09
Canada	442	1.34***	0.60***	-0.06***	11.20	13.45***	5.31*	.36
China, Hong Kong	191	1.17***	0.79***	-0.21***	2.94	10.79***	4.83	.13
Colombia	176	3.26**	-0.69	-0.08***	8.31	4.36**	13.33***	.04
Côte d'Ivoire	411	0.73***	0.30***	-0.07***	9.55	8.13***	13.13***	.09
Denmark	442	1.31***	0.35***	-0.13***	4.98	16.19***	10.19***	.08
Dominica	356	0.01***	0.00019	-0.02***	34.31	3.28**	3.29	.01
Dominican Republic	165	-1.29	0.05	-0.03	22.76	1.25	24.07***	.004
Egypt	152	-0.15	0.31	-0.14***	4.60	6.16***	1.22	.07

	No. of obs.	*γ*	*β*	*θ*	*Half life*	*F*	*Stability*	*Adj R^2*
El Salvador	112	1.02***	-0.65	-0.29***	2.02	9.79***	6.80**	.14
Ethiopia	283	-0.28	-0.20	-0.01	68.97	1.21	9.26***	.006
Fiji	414	0.38**	0.02	-0.08***	8.31	9.10***	5.09*	.04
Finland	384	1.48***	0.25***	-0.04***	16.98	10.01***	8.37***	.05
France	443	1.65***	0.06***	-0.03***	22.76	7.37***	20.32***	.04
Germany	442	0.69***	0.07	-0.09***	7.35	13.33***	16.06***	.06
Ghana	375	2.06	0.016	-0.006	115.18	1.20	15.20***	.001
Grenada	357	0.06	0.0001	-0.05***	13.51	5.55***	3.12	.03
Guatemala	111	0.31	-1.16	-0.34***	1.67	11.56***	3.68	.16
Indonesia	322	1.02	-0.12	-0.06***	11.20	5.66***	2.13	.03
Israel	297	4.16	4.59**	-0.05***	13.51	8.86***	6.29**	.08
Italy	442	2.64***	0.046	-0.02***	34.31	7.58***	11.81***	.03
Jamaica	442	-0.67	-0.03	-0.02**	34.31	2.65*	3.18	.007
Japan	442	0.93***	-0.001	-0.01***	68.97	6.56***	2.66	.03
Kenya	439	0.73	-0.007	-0.02**	34.31	2.42*	6.20**	.006
Korea, Republic	398	1.34**	0.15*	-0.02**	34.31	2.54*	2.24	.01
Kuwait	369	0.82***	0.41***	-0.06***	11.20	7.64***	7.15**	.19
Lao People's Rep	169	1.68*	0.43	-0.07***	9.55	3.92**	4.25	.04
Lebanon	333	1.52*	-0.14	-0.03***	22.76	3.53**	18.64***	.02
Lesotho	353	0.93***	0.28***	-0.12***	5.42	17.76***	16.23***	.14
Luxembourg	111	0.96***	0.79***	-0.37***	1.50	13.21***	7.32**	.75
Madagascar	223	0.70	0.20	-0.02*	34.31	1.57	6.40**	.01
Malawi	321	-0.41	-0.20	-0.03**	22.76	2.28	1.83	.01
Malaysia	437	0.27**	-0.04	-0.12***	5.42	14.63***	8.60***	.06
Mali	411	0.74***	0.31***	-0.07***	9.55	8.13***	13.13***	.09
Malta	261	-0.56	0.07**	0.01**	68.97	2.32	55.44***	.03
Mauritius	369	0.71***	-0.02	-0.05***	13.51	5.29***	2.97	.03
Mexico	382	5.74**	0.18	-0.02***	34.31	3.65**	35.01***	.01
Morocco	188	0.31	0.09	-0.03**	22.76	2.86*	8.51***	.02
Mozambique	139	6.44	-0.15	-0.03***	22.76	7.38***	1.56	.09
Namibia	215	1.06***	0.76***	-0.19***	3.29	16.01***	10.97***	.65
Nepal	329	0.20	0.01	-0.04***	16.98	3.84**	18.91***	.02

	No. of obs.	γ	β	θ	Half life	F	Stability	Adj R^2
Netherlands	311	0.88***	0.06	-0.21***	2.94	22.48***	7.01***	.12
Netherlands Antilles	332	0.58***	0.02	-0.08***	8.31	9.98***	5.59*	.05
New Zealand	382	1.06***	0.15**	-0.07***	9.55	9.71***	6.44**	.05
Niger	411	0.73***	0.28***	-0.07***	9.55	7.82***	12.01***	.08
Nigeria	215	2.29	-0.40	-0.02*	34.31	1.59	2.22	.01
Norway	440	0.85***	0.04	-0.09***	7.35	11.13***	7.92**	.04
Pakistan	442	0.10	-0.17	-0.29***	2.02	37.43***	9.43***	.14
Paraguay	228	1.50*	0.44	-0.16***	3.98	9.71***	6.74**	.07
Philippines	405	1.85***	0.07	-0.03***	22.76	6.68***	12.74***	.03
Poland	227	1.70	1.35**	-0.04***	16.98	4.08**	8.54***	.04
Portugal	206	1.72**	0.23	-0.09***	7.35	5.16***	20.05***	.04
Romania	177	6.36*	0.34	-0.08***	8.31	3.67**	8.78***	.03
Senegal	411	0.73***	0.27***	-0.07***	9.55	7.81***	11.43***	.08
Seychelles	363	0.69	-0.08	-0.01*	68.97	1.49	10.46***	.008
Singapore	434	-0.06	0.02	-0.04***	16.98	4.34**	8.08**	.02
South Africa	442	3.37*	0.08*	-0.01***	68.97	12.02***	8.04**	.05
Spain	430	1.35***	-0.17	-0.10***	6.58	11.30***	11.31***	.05
Sri Lanka	371	0.30	-0.18	-0.24***	2.53	26.16***	6.69**	.12
St. Kitts and Nevis	356	-0.01	-0.005	-0.02*	34.31	1.85	12.17***	.006
St. Lucia	356	0.02	-0.002	-0.13***	4.98	11.75***	11.37***	.06
St. Vincent & Grens.	358	0.09**	0.006	-0.09***	7.35	9.65***	9.68***	.05
Swaziland	333	0.92***	0.25***	-0.09***	7.35	16.84***	11.27***	.16
Sweden	435	1.30***	-0.10**	-0.03***	22.76	5.12***	6.88**	.04
Switzerland	409	0.55***	-0.017	-0.09***	7.35	9.53***	17.67***	.04
Tanzania	190	0.70	2.46***	-0.06***	11.20	4.21**	9.85***	.06
Thailand	394	1.40***	0.46***	-0.09***	7.35	10.53***	5.95*	.08
Togo	411	0.73***	0.28***	-0.07***	9.55	7.85***	12.17***	.08
Tunisia	310	0.80***	0.06	-0.04***	16.98	8.90***	2.31	.05
Turkey	283	3.88**	3.58	-0.22***	2.79	17.30***	10.36***	.11
Uganda	358	3.11	0.08	-0.01**	68.97	3.01*	14.39***	.01
United Kingdom	442	-1.43	0.004	-0.002	346.23	0.33	13.26***	.0001
Uruguay	200	1.02	1.05	-0.09	7.35	4.81***	17.50***	.04

	No. of obs.	γ	β	θ	Half life	F	Stability	Adj R^2
Venezuela, Rep.	166	-0.45	-0.43	-0.28***	2.11	13.79***	8.81***	.14
Zambia	379	-1.08	-0.28	-0.01*	68.97	1.74	6.71*	.006
Zimbabwe	349	-14.01	0.23	-0.01*	68.97	1.70	5.69*	.004
ERR								
Pegs (average)		0.60	0.17	-0.10	10.68	10.12	10.11	0.11
Occ. pegs (average)		0.80	-0.01	-0.09	22.36	9.32	13.04	0.08
Non-pegs (average)		1.31	0.36	-0.05	36.74	6.70	8.96	0.04
Capital Market								
Open (average)		1.22	0.07	-0.14	19.65	9.29	10.15	0.20
Occ. (average)		1.22	0.18	-0.08	29.64	8.71	12.69	0.05
Closed (average)		0.75	0.26	-0.07	24.40	8.15	9.03	0.07

*** Significant at the 1%, ** at the 5% and * at the 10% significance level
The Average Wald F-statistic is reported for the stability (Quandt-Andrews breakpoint) test
Half-life is calculated as follows: $\ln(0.5)/\ln(1-|\theta|)$

Chapter 2: The Exchange Rate Disconnect Puzzle Revisited

2.1. Motivation and Literature

The exchange rate disconnect puzzle has been widely studied in the international macroeconomic literature. Theories stipulate that, in the long-run, exchange rates are determined by fundamentals such as output, money supply, interest rates and prices. Empirical results, however, do not support such a relationship. This chapter tries to fill this gap using new econometric techniques. In order to motivate the significance of our findings, we use the same dataset of the seminal paper of Engel and West (2005) which studied the same puzzle, and compare our results to theirs.

Engel and West (2005) employed the standard Johansen and Juselius (1990) approach to cointegration to test for a long-run relationship between the exchange rate of six industrialized countries and a number of fundamental variables as hypothesized by the monetary approach to exchange rate determination. Specifically, they conduct six multivariate equations, one for each country against the whole set of fundamentals; relative money supplies, relative output, the interest rate differential and the inflation differential of each country against the United States which is considered the base country. They also conduct bivariate equations of the exchange rate of each country against each and every fundamental variable separately. An important precondition in the Johansen approach is that variables need all be *I(1)* in levels and *I(0)* in first-differences.

We show that we fail to reject the null of a unit root in some of the above mentioned variables, while the null is rejected in some other variables.

In this chapter, we use the same dataset as in Engel and West (2005), but the difference is that we suggest using the Autoregressive Distributed Lag *(ARDL)* approach to cointegration developed by Pesaran et al (2001) as opposed to the standard Johansen approach. The advantage of this approach is that it is directly applicable irrespective of whether the variables of interest are purely stationary, or first-difference stationary or mutually cointegrated. This property helps avoid some econometric problems that arise when using the traditional Johansen approach as will be discussed below in detail.

This chapter presents strong support for the monetary model of exchange rate determination. Specifically, an *ARDL* model is first estimated to study the long-run and short-run relationship between exchange rates and fundamentals. Using Pesaran et al's (2001) *F-statistic* procedure to test for the significance of lagged level variables in a conditional error-correction format, as well as examining the sign and significance of the lagged error correction term we find evidence of cointegration in 20 bivariate relationships between exchange rates in the six countries and each of the four fundamentals as opposed to only 5 in the Engel and West paper. We also find cointegration based on multivariate relationships in all 6 countries as opposed to almost none in the Engel and West paper.

Furthermore, we conduct a number of Granger causality tests examining the direction of causality between exchange rates and fundamentals, both in the short-run and the long-run. Again, our results improve on those of Engel and West (2005), as we find evidence that fundamentals help predict exchange rates in all six countries, in both the short-run and long-run. This finding contrasts with that of Engel and West as they mainly find evidence of Granger causality going in the opposite direction.

The remainder of the chapter is structured as follows. Section 2 presents the alternative theories and reviews the literature. Section 3 presents the econometric methodologies and results. Finally, section 4 concludes.

2.2. Monetary Approach to Exchange Rate Determination: Theory & Empirics

At the start of the post Bretton-Woods era, the monetary (or asset) approach to the exchange rate emerged as the dominant exchange rate model; that exchange rates move to equilibrate any disequilibrium in the international money (asset) markets.[16] There are generally two versions of the monetary approach to the exchange rate, and this section will outline both the theory and the empirics behind them.

[16] See Taylor (1995), Rogoff (1999) and Neely and Sarno (2002) for a comprehensive review of the theory and evidence.

2.2.1. Monetary Approach to Exchange Rate Determination: Theory

The first version of the monetary approach is the so-called "Chicago" theory or the flexible-price monetary model introduced by Frenkel (1976) and Bilson (1978a, 1978b). The second is the "Keynesian" theory or the sticky-price monetary model developed by Dornbusch (1976), which was later modified by Frankel (1979) and termed the real interest differential model.

2.2.1.1. The Flexible-price Monetary Model

The flexible-price monetary theory is based on two core building blocks: a simple money demand function and the purchasing power parity (PPP) condition. The quantity theory of money posits that prices are determined by equilibrium in the money market. This is represented by the following money demand functions, one for the domestic and the other for the foreign country:

$$m_t - p_t = \phi y_t - \lambda i_t \qquad (2.1)$$

$$m^*_t - p^*_t = \phi y^*_t - \lambda i^*_t \qquad (2.2)$$

where m, p and y represent the *log* of the domestic stock of money, price level, and output, while i is the interest rate and an asterisk denotes the corresponding variables of the foreign country. The income elasticity of money demand is represented by ϕ, while λ represents the interest rate semi-elasticity of money demand.

The second equation is the PPP condition where the spot nominal exchange rate, s_t, defined as the price of foreign currency, equals the difference between the domestic, p_t, and the foreign price levels, p^*_t

$$s_t = p_t - p^*_t \tag{2.3}$$

Solving equations (2.1) and (2.2) for p_t and p^*_t, substituting into equation (2.3) and adding an error term yields the flexible-price monetary theory of exchange rate:

$$s_t = (m_t - m^*_t) - \phi(y_t - y^*_t) + \lambda(i_t - i^*_t) + u_t \tag{2.4}$$

Equation (2.4) assumes that the domestic and foreign countries both have the same money demand coefficients. This flexible-price monetary equation adopted by Bilson (1978a, 1978b) basically says that, in equilibrium, the spot exchange rate is a function of the relative money supplies, relative incomes and the relative price levels. As such, an increase in domestic money supply over that of the foreign country leads to exchange rate depreciation of the domestic currency, while an increase in the domestic over the foreign output level leads to an appreciation of the domestic currency, and finally an increase in the domestic interest rate leads to a depreciation of the domestic currency.

Frenkel (1976), on the other hand, assumes a Cagan-type money demand function, in which he uses the expected inflation rate instead of the interest rate as follows:

$$m_t - p_t = \phi y_t - \lambda \pi_t \tag{2.5}$$

with a similar equation for the foreign country. Going through the exact same procedure as above, we arrive at Frenkel's (1976) exchange rate equation for the flexible-price monetary model, that is very similar to the one derived in Bilson's (1978a, 1978b) framework, except that we replace the interest rate differential with the expected inflation rate differential

$$s_t = (m_t - m^*_t) - \phi(y_t - y^*_t) + \lambda(\pi_t - \pi^*_t) + u_t \tag{2.6}$$

2.2.1.2. The Sticky-price Monetary Model

The alternative class of monetary models to exchange rate due originally to Dornbusch (1976), and later on modified by Frankel (1979), assumes that prices are rigid, and thus the adjustment process of the exchange rate to its long-run level is slow following any short-run disequilibrium. Specifically, this sticky-price monetary approach stipulates that the nominal exchange rate in the short-run will overshoot its long-run level associated with the PPP condition. These models assume the following Uncovered Interest Parity (UIP) condition

$$E(s_{t-1} - s_t) = i_t - i^*_t \tag{2.7}$$

Frankel (1979) then assumes that the above equation is a function of the gap between the spot nominal exchange rate and its long-run equilibrium level, and of the long-run inflation differential between the domestic and foreign countries. Using bars to indicate equilibrium (long-run) levels, this is represented as follows:

$$E(s_{t-1} - s_t) = -\theta(s_t - \bar{s}) + (\pi_t - \pi^*_t) \quad (2.8)$$

According to Frankel (1979), the above equation simply says that in the short-run the exchange rate will return to its long-run equilibrium level at a rate that is proportional to the current gap as defined by θ, the speed of adjustment in the goods market. Putting equation (2.7) into (2.8) and solving for $(s_t - \bar{s})$ yields

$$(s_t - \bar{s}) = -\frac{1}{\theta}[(i_t - \pi_t) - (i^*_t - \pi^*_t)] \quad (2.9)$$

Frankel (1979) describes the expression in brackets on the RHS as the real interest differential. Then, writing the PPP equation in its long-run form

$$\bar{s} = \bar{p} - \bar{p}^* = (\bar{m} - \bar{m}^*) - \phi(\bar{y} - \bar{y}^*) + \lambda(\bar{\imath} - \bar{\imath}^*) \quad (2.10)$$

In the long-run when $s_t = \bar{s}$, we'll have $(\bar{\imath} - \bar{\imath}^*) = (\pi_t - \pi^*_t)$, this along with the assumption that the equilibrium levels of money supply and income are given by their current period values, yields the following equation

$$\bar{s} = p_t - p^*_t = (m_t - m^*_t) - \phi(y_t - y^*_t) + \lambda(\pi_t - \pi^*_t) \qquad (2.11)$$

Substituting the equilibrium exchange rate level defined by equation (2.11) into equation (2.9) yields

$$s_t = (m_t - m^*_t) - \phi(y_t - y^*_t) - \frac{1}{\theta}(i_t - i^*_t) + (\frac{1}{\theta} + \lambda)(\pi_t - \pi^*_t) \qquad (2.12)$$

Adding an error term, we get the Frankel (1979) real interest differential equation:

$$s_t = (m_t - m^*_t) - \phi(y_t - y^*_t) - \gamma(i_t - i^*_t) + \beta(\pi_t - \pi^*_t) + u_t \qquad (2.13)$$

where $\gamma = (-\frac{1}{\theta})$ and $\beta = (\frac{1}{\theta} + \lambda)$, and β is assumed greater than α in absolute value. Dornbusch's (1976) model is of exactly the same framework except that it assumes that the inflation rate differential is equal to zero in the above equation.

Our main equations of interest are equations (2.4) and (2.6) of the flexible-price model, and equation (2.13) of the sticky-price model. The major difference is in the relationship between the exchange rate and the nominal interest rate differential. In the *Chicago theory*, since prices are flexible, a rise in the domestic relative to the foreign interest rate reflects a corresponding rise in the domestic relative to the foreign inflation rates. As such, an increase in domestic interest rates leads to a fall in the demand for the domestic relative to the foreign currency, causing it to depreciate. Thus, there is a *positive* relationship between the exchange rate and the interest rate differential.

On the other hand, in the *Keynesian theory*, since prices are sticky, posits that a rise in the domestic relative to the foreign interest rate reflects a drop in domestic money supply. Prices in the goods market will not adjust instantaneously, but will gradually fall. As such, an increase in domestic interest rates relative to its foreign counterpart will cause capital inflow, causing an appreciation in the domestic currency. Thus, there is a *negative* relationship between the exchange rate and the interest rate differential. Table (2.1) below provides a concise summary of the alternative monetary theories to exchange rate determination.

Table 2.1: Summary of Monetary Models of the Exchange Rate

	$s_t = \eta(m_t - m^*_t) + \phi(y_t - y^*_t) + \gamma(i_t - i^*_t) + \beta(\pi_t - \pi^*_t)$			
	Money Supply Differential	***Output Differential***	***Interest Rate Differential***	***Expected Inflation Differential***
Flexible-price models				
Frenkel (1976)	$\eta = 1$	$\phi < 0$	$\gamma = 0$	$\beta > 0$
Bilson (1978a, 1978b)	$\eta = 1$	$\phi < 0$	$\gamma > 0$	$\beta = 0$
Sticky-price models				
Dornbusch (1976)	$\eta = 1$	$\phi < 0$	$\gamma < 0$	$\beta = 0$
Frankel (1979)	$\eta = 1$	$\phi < 0$	$\gamma < 0$	$\beta > 0 > \lvert\gamma\rvert$

Source: Based on Frenkel and Koske (2004) and Frankel (1979)

2.2.2. Monetary Approach to Exchange Rate Determination: Empirics

Bahmani-Oskooee et al (2010) listed two conditions if one is to present empirical support for the monetary model to exchange rate determination; evidence of cointegration (long-run co-movement) between the exchange rate and fundamentals, as well as parameters showing the proper sign and significance in the long-run relationship. The majority of studies to date have applied the Johansen (1988) and Johansen and Juselius (1990) approach to cointegration to test the different versions of the monetary exchange rate model.

Rapach and Wohar (2002) using a sample of 14 countries tested the coefficients of the relative money supplies and income levels, but did not study those of the interest rate and inflation differentials. Frankel (1979) found support for the real interest differential model on the mark/dollar exchange rate using monthly data between 1974M7-1978M2. Frenkel and Koske (2004) test the monetary model for the euro against six major currencies using quarterly data covering the period 1980Q1-2003Q2. Using trace and maximum eigenvalue tests, they were able to report evidence of a cointegrating relationship in the currencies of five out of the six countries. Their estimates show that the Euro versus the Canadian dollar and Swiss Franc support the real interest differential version of the model, while results for the rest of their sample are inconclusive as coefficients do not always show the appropriate sign and significance.

A number of studies have reported support for the flexible-price version of the monetary model. Tawadros (2001) found such evidence for the flexible for the Australian dollar against the US dollar using monthly observations over the period 1984M1-1996M1. Islam and Hasan (2006) for the dollar-yen exchange rate over the period 1974Q1-2003Q1. The Canadian versus US dollar has been widely studied, but the results are mixed. Francis et al (2001) and Diamandis et al (1996) during the periods 1974-1993 and 1970-1994, respectively, used the Johansen (1988) and Johansen and Juselius (1990) approach to cointegration. Cushman (2000), however, did not find support for the monetary exchange rate model since 1970 till end 1990's.

2.3. Econometric Methodology and Results

Empirical literature presented in the previous section show that results are mixed at best. In this section, we make use of recent developments in the time-series techniques that allow us to better test our theories. We use the Autoregressive Distributed Lag *(ARDL)* approach to cointegration developed by Pesaran et al (2001) and empirically test the validity of the monetary theories to exchange rate determination. To provide direct comparison with the Johansen methodology, we compare our results to those in the seminal study by Engel and West (2005).

2.3.1. The Time-Series Properties

Engel and West (2005) use a dataset of six industrialized countries, covering quarterly data from 1974Q1 to 2001Q3.[17] Specifically, they examine the relationship between the exchange rates, (s_{it}), of $i=1, \dots 6$ countries; Canada, France, Germany, Italy, Japan and the United Kingdom against the U.S. exchange rate, and the set of fundamentals identified above; money supply differential $(m - m^*)_{it}$, output differential $(y - y^*)_{it}$, interest rate differential $(i - i^*)_{it}$, and they use consumer prices as a proxy for the expected inflation differential $(\pi - \pi^*)_{it}$, between each domestic country and the U.S. as the foreign country. Data sources are shown in their paper (see Engel and West (2005, pp.499-500)).

[17] The dataset is available online on Charles Engel's website.

Before running any regressions, an examination of the order of integration of the time-series variables is required.[18] The Augmented Dickey Fuller (ADF) unit root test is used to establish the stationarity of the variables used in the empirical analysis. All variables, except the interest rate, are expressed in log terms. Results reported in Table (2.2) show that we have a combination of variables being *I(1)* and *I(0)*. This finding creates an econometric concern if one would to utilize the Johansen approach to cointegration as all variables need to be *I(1)* in levels and *I(0)* in first-differences. We argue that this econometric detail may be driving the weak cointegration results reported in Engel and West (2005), and propose using the ARDL approach to cointegration of Pesaran et al (2001). As mentioned earlier, the ARDL methodology can be applied irrespective of the order of the integration of the variables, and thus is very useful in our preset context.

2.3.2. The ARDL Methodology

As in Engel and West (2005), we examine 6 multivariate equations, one for each country, between the exchange rate and the whole set of fundamentals. Moreover, we estimate 24 bivariate equations, four per country, between the exchange rate and every fundamental. We begin by estimating the following long-run model for our 6 countries using the *ARDL* procedure:

$$s_{it} = \alpha + \eta(m - m^*)_{it} + \phi(y - y^*)_{it} + \gamma(i - i^*)_{it} + \beta(\pi - \pi^*)_{it} + u_{it} \qquad (2.14)$$

[18] If a variable has a unit root (is non-stationary), then the OLS estimates will be biased downward, and the reported standard errors will be tighter than the actual, leading to over-rejection.

Since we are interested in studying the cointegration relationship between the exchange rate and the fundamentals, we re-write equation (2.14) in a constrained error-correction format. In doing so, we are able to distinguish the long-run from the short-run effects of fundamentals on the exchange rate. We follow the bounds testing approach of Pesaran et al (2001) as outlined by the $ARDL(n_1,n_2,n_3,n_4,n_5)$ specification (2.15):

$$\Delta s_{it} = \alpha + \sum_{k=1}^{n1} \omega_{ik} \Delta s_{i,t-k} + \sum_{k=0}^{n2} \eta_{ik} \Delta(m - m^*)_{i,t-k} + \sum_{k=0}^{n3} \phi_{ik} \Delta(y - y^*)_{i,t-k} + \sum_{k=0}^{n4} \gamma_{ik} \Delta(i - i^*)_{i,t-k} + \sum_{k=0}^{n5} \beta_{ik} \Delta(\pi - \pi^*)_{i,t-k} + \delta_1 s_{it-1} + \delta_2 (m - m^*)_{it-1} + \delta_3 (y - y^*)_{it-1} + \delta_4 (i - i^*)_{it-1} + \delta_5 (\pi - \pi^*)_{it-1} + \varepsilon_{it} \quad (2.15)$$

Table 2.2: Unit Root Tests

	Levels					First Differences				
	(s)	$(m\text{-}m^*)$	$(y\text{-}y^*)$	$(i\text{-}i^*)$	$(\pi\text{-}\pi^*)$	*(s)*	$(m\text{-}m^*)$	$(y\text{-}y^*)$	$(i\text{-}i^*)$	$(\pi\text{-}\pi^*)$
Canada	-1.153	0.249	-0.928	-2.58*	-1.798	-10.59***	-4.79***	-11.24***	-15.33***	-6.23***
France	-1.399	-1.36	-0.432	-2.74*	-2.063	-9.27***	-3.89***	-8.53***	-11.86***	-6.41***
Germany	-1.767	-0.267	-1.172	-1.636	-1.901	-9.63***	-3.84***	-9.52***	-6.30***	-3.16**
Italy	-1.664	-4.36***	0.317	-1.467	-2.69*	-8.94***	-7.27***	-8.97***	-4.41***	-1.419
Japan	-1.185	-0.986	-0.515	-2.77*	-0.696	-9.03***	-3.99***	-9.74***	-5.68***	-3.32**
UK	-2.370	-1.295	-1.199	-4.18***	-3.26**	-8.95***	-5.37***	-10.84***	-12.21***	-4.79***

*** Significant at the 1% significance level, ** Significant at 5%, * Significant at 10%

Numbers reported are the computed t-statistics for ADF tests, and p-statistic for ERS test. The null hypothesis in both tests is the series contains a unit root.

In this framework, the short-run coefficients (attached to first-differenced variables) and the long-run coefficients (attached to lagged level variables) are simultaneously estimated by applying Ordinary Least Squares to (2.15). The long-run coefficients are produced by using $\hat{\delta}_2$, $\hat{\delta}_3$, $\hat{\delta}_4$ and $\hat{\delta}_5$ which are normalized by $\hat{\delta}_1$.[19] Of course, we need to establish cointegration among the variables for the long-run coefficients to be valid. Pesaran et al (2001) propose the standard *F-test* for the joint significance of lagged level variables for the cointegration test, with new non-standard critical values that they tabulate in their paper.

An advantage of this procedure is that it is applied irrespective of whether the variables are *I(1)* or *I(0)*. We can thus avoid all pre-unit-root testing associated with the standard cointegration approach of Johansen and Juselius (1990), which was applied in the Engel and West (2005) paper. When applying the Johansen methodology in their paper, they started with the Dickey-Fuller unit root tests and were unable to reject the null of a unit root in any of their measures of fundamentals, yet they conduct their analysis using both interest rate differentials in levels and first-differences arguing that they are uneasy using interest rate differentials only in the differenced form. In the *ARDL* methodology, however, this problem would not arise.

[19] See Bahmani-Oskooee and Tanku (2008) for a step-by-step explanation of the method and normalization procedure. It is worth noting that the standard error of the ratio of two coefficients is not the ratio of two standard errors. Pesaran and Pesaran (1997, pp.394-404) illustrate how the standard errors of normalized coefficients are calculated using non-linear least squares and the Delta method.

Specifically, Pesaran et al (2001) report two sets of critical values; an upper bound critical value assuming all variables are *I(1)*, and a lower bound assuming all are *I(0)*. If the calculated *F-statistic* is above the upper bound, then the variables are jointly significant indicating long-run cointegration. If the calculated statistic is below the lower bound critical value, there is no cointegration. If, however, the calculated F-statistic lies in between these two bounds, then the results are inconclusive, and we can perform an alternative test by forming a lagged error-correction term in place of the linear combination of lagged level variables in equation (2.15). Each model is then re-estimated using the same number of optimum lags derived from above:

$$\Delta s_{it} = \alpha + \sum_{k=1}^{n1} \omega_{ik}\, \Delta s_{i,t-k} + \sum_{k=0}^{n2} \eta_{ik}\, \Delta(m - m^*)_{i,t-k} + \sum_{k=0}^{n3} \phi_{ik}\, \Delta(y - y^*)_{i,t-k} + \sum_{k=0}^{n4} \gamma_{ik}\, \Delta(i - i^*)_{i,t-k} + \sum_{k=0}^{n5} \beta_{ik}\, \Delta(\pi - \pi^*)_{i,t-k} + \rho_i\, ECM_{it-1} + \varepsilon_{it} \qquad (2.16)$$

In this new specification, one can examine the direction and speed of adjustment in the model following any short-run disequilibrium by examining the sign and significance of the ECM_{it-1} coefficient. The ECM_{it-1} basically links the long-run equilibrium implied by the cointegration relationship with the short-run adjustment process describing the mechanism by which the variables react following any shock that takes them off the long-run equilibrium. In the context of equation (2.16) above, a negative and significant $\hat{\rho}_i$, indicates adjustment of the exchange rate toward the long-run equilibrium following any short-run disequilibrium. Finally, the higher the absolute value of $\hat{\rho}_i$, the faster the adjustment process or the convergence rate.

2.3.3. The ARDL Results

We estimate two versions of equations (2.14)-(2.16) above. In the first, we examine the multivariate relationship between the exchange rate and our four fundamentals, for each of the six countries in our dataset. In the second, we examine the bivariate relationship between the exchange rate and each of the four fundamentals separately. So we estimate 24 (6 countries and 4 fundamentals) regressions in this step. In choosing the number of lags, we follow Bahmani-Oskooee and Tanku (2008) and minimize the Akaike Information Criterion (AIC), imposing a maximum of 4 lags since we're using quarterly data. We report the long-run coefficient estimates and cointegration tests in Table (2.3).[20]

[20] We do not report the short-run coefficient estimates for brevity, but results are available upon request.

Table 2.3: Results from the ARDL Model

	Model	Data	ARDL	cons	$(m\text{-}m^*)$	$(y\text{-}y^*)$	$(i\text{-}i^*)$	$(\pi\text{-}\pi^*)$	F	ECM_{t-1}	Adj R^2
Canada	***multivariate***	76Q1-01Q3	*ARDL(1,0, 0,0,0)*	1.33	.09	-2.48*	-1.71	-.42	1.87	-.07***	.05
	(m-m*)	75Q1-01Q3	*ARDL(1,0)*	-180.1	.53				1.79	-.03*	.016
	(y-y*)	75Q1-01Q3	*ARDL(1,0)*	39.5***		-3.1***			2.82*	-.05**	.04
	(i-i*)	76Q1-01Q3	*ARDL(1,0)*	40.6***			-5.9		2.35	-.04**	.02
	(π-π*)	75Q1-01Q3	*ARDL(1,3)*	40.1**				-2.38	1.49	-.02*	.04
France	***multivariate***	79Q1-98Q4	*ARDL(4,1, 3,0,3)*	156.7***	.38*	-.59	-1.32*	1.63***	5.18***	-.31***	.34
	(m-m*)	79Q1-98Q4	*ARDL(4,2)*	140.9***	.67				2.63*	-.08**	.13
	(y-y*)	75Q1-01Q3	*ARDL(4,0)*	182.7***		-.39			2.16	-.06**	.05
	(i-i*)	75Q1-01Q3	*ARDL(4,1)*	185.5***			-3.33		2.54*	-.05**	.09
	(π-π*)	75Q1-01Q3	*ARDL(1,1)*	180.15***				.14	1.33	-.04	.04
Germany	***multivariate***	75Q1-98Q4	*ARDL(1,4, 0,0,2)*	27.34	-.35	7.14	-17.44	-1.52	2.48**	-.05***	.18
	(m-m*)	75Q1-98Q4	*ARDL(4,4)*	173.9	.98				1.29	-.04	.11
	(y-y*)	75Q1-01Q3	*ARDL(4,0)*	67.1***		.41			1.76	-.05*	.05
	(i-i*)	75Q1-01Q3	*ARDL(4,0)*	55.9***			-5.3**		3.21**	-.07**	.09
	(π-π*)	75Q1-01Q3	*ARDL(4,0)*	62.2***				.41	2.0	-.07**	.06
Italy	***multivariate***	79Q3-98Q4	*ARDL(4,3, 4,0,2)*	650.9*	.12	-1.37	-1.35	.13	3.64***	-.16***	.36
	(m-m*)	76Q1-98Q4	*ARDL(2,1)*	588.1**	.24				3.96**	-.07***	.08
	(y-y*)	75Q1-01Q3	*ARDL(2,0)*	746.6***		-1.99			1.79	-.04*	.03
	(i-i*)	79Q3-01Q3	*ARDL(4,1)*	746.8***			-2.19		2.26	-.05**	.15
	(π-π*)	75Q1-01Q3	*ARDL(2,1)*	742.1***				1.03***	2.13	-.07**	.06
Japan	***multivariate***	79Q3-01Q3	*ARDL(3,0, 0,2,1)*	-724.7	2.25	9.97	-21.12	.85	4.36***	-.06***	.27
	(m-m*)	75Q1-01Q3	*ARDL(1,1)*	-722.1	2.33				.61	-.01	.05
	(y-y*)	75Q1-01Q3	*ARDL(4,1)*	483.4***		-2.52			1.89	-.03*	.07
	(i-i*)	79Q3-01Q3	*ARDL(1,0)*	379.2***			-28.3		7.79***	-.03***	.13
	(π-π*)	75Q1-01Q3	*ARDL(4,1)*	460.9***				1.44**	1.34	-.06	.11
UK	***multivariate***	75Q1-01Q3	*ARDL(4,1, 0,0,0)*	-251.1	.34	.06	-3.96	-.97	3.34***	-.12***	.19

Model	***Data***	***ARDL***	***cons***	***$(m-m^*)$***	***$(y-y^*)$***	***$(i-i^*)$***	***$(\pi-\pi^*)$***	***F***	***ECM_{t-1}***	***Adj R^2***
$(m-m^*)$	75Q1-01Q3	*ARDL(4,2)*	-116.9*	.11				4.68**	-.12***	.17
$(y-y^*)$	75Q1-01Q3	*ARDL(4,0)*	-46.1***		-1.16**			5.04***	-.13***	.13
$(i-i^*)$	75Q1-01Q3	*ARDL(4,0)*	-41.56***			-3.56*		5.40***	-.09***	.15
$(\pi-\pi^*)$	75Q1-01Q3	*ARDL(4,0)*	-46.1***				.42	4.53**	-.12***	.12

Notes: *** significant at the 1% significance level, ** significant at 5%, * significant at 10%

If we first consider the *multivariate* equations, we find evidence of a long-run relationship between exchange rate and its fundamentals in 5 out of 6 countries using the *F-test*, and in all six countries if we look at the negative and significant lagged error correction term. Looking at the coefficients of the fundamentals to see whether they show the proper sign or not, we can see that the coefficient on the money supply differential shows the correct positive sign in 5 countries, but is only significant in the case of France. Output differential coefficients show the correct negative sign twice, and is only significant once in the case of Canada. The coefficients on the interest rate differential are correct in all six countries, but show significance only in France. Finally, the coefficient on the consumer price differential shows the correct sign in three cases, but is only significant in France. As such, if we contrast these results to the ones hypothesized in Table (2.1) above, we find that France strongly follows Frankel's (1979) version of the sticky-price monetary approach to exchange rate determination. Italy shows all the signs predicted by Frankel's (1979) real interest differential model, yet no coefficients are statistically significant. Canada and Japan slightly follow the predictions of sticky-price models, while Germany and the UK do not seem to follow any clear hypothesis.

If we now turn to the *bivariate* equations, we can see evidence of cointegration in 10 out of 24 cases using the F-test, and 20 out of 24 by examining the sign and significance of the lagged error correction term. Regarding the signs and significance of the coefficients on each of the fundamentals, we find that all, except the inflation differential in Canada and output differential in Germany, show the signs hypothesized by the real interest differential model introduced by Frankel (1979). Out of these 22 equations, however, only 6 are statistically significant. Moreover, we report the *adjusted* R^2 for each model, and they all show a reasonable fit. Finally, it is worth mentioning that we performed a number of diagnostic tests along the lines of Bahmani et al (2005) to show that our models are correctly specified. Our results reveal that the models are mostly free from serial correlation, misspecification and parameter instability as indicated by the Lagrange Multiplier (LM) test, Ramsey's RESET test and the cumulative sum (CUSUM) and CUSUM of squares (CUSUMSQ) tests of Brown et al (1975), respectively.[21]

A final note to make is that in all our equations, multivariate or bivariate, the coefficient on the lagged error correction term has been negative and highly significant. This implies that following any disequilibrium from the long-run path, it is the exchange rate that adjusts to restore the equilibrium not the fundamentals.

These findings present a significant improvement over comparable results from Engel and West (2005). In their paper, using trace and maximum eigenvalue statistics from the Johansen approach to cointegration, they find almost no evidence of cointegration in the multivariate case, and only 5 out of 24 cases in the bivariate cases. However, using the exact same dataset but employing the *ARDL* approach to cointegration, we report cointegration in all 6 multivariate cases, and 20 out of 24 bivariate cases.

[21] Again, these results are omitted for space considerations, but they are available upon request.

2.3.4. Granger Causality Tests

Our results so far have confirmed a long-run relationship between the exchange rate and fundamental determinants in our dataset of six industrialized countries, re-enforcing the predictions of the monetary approach to exchange rate determination. A natural step is now to test the adequacy of our estimated model. Following Engel and West (2005), we perform multivariate and bivariate Granger causality tests, and compare our results to theirs.

Granger (1988) argued that Granger causality must exist in at least one direction as long as the variables of the system are cointegrated. This, however, doesn't tell us anything about the direction of causality between the two variables. This is why we need to represent the system in an error-correction form. Following the *ARDL* methodology of Pesaran et al (2001, p.293), we can re-write the system as follows

$$\Delta s_{it} = \alpha + \sum_{k=1}^{n1} \omega_{ik} \Delta s_{i,t-k} + \sum_{k=0}^{n2} \eta_{ik} \Delta(fund - fund^*)_{i,t-k} + \rho_i ECM_{it-1} + \varepsilon_{it} \quad (2.17)$$

$$\Delta fund_t = \alpha' + \sum_{k=1}^{n1} \omega'_{ik} \Delta s_{i,t-k} + \sum_{k=1}^{n2} \eta'_{ik} \Delta(fund - fund^*)_{i,t-k} + \rho'_i ECM_{it-1} + \mu_{it} \quad (2.18)$$

where $\Delta(fund - fund^*) = \Delta(m\text{-}m^*)$, $\Delta(y\text{-}y^*)$, $\Delta(i\text{-}i^*)$ and $\Delta(\pi\text{-}\pi^*)$ in the 6 multivariate cases, and a single fundamental variable in the 24 bivariate cases. We use the same optimal number of lags indicated by AIC from the previous section.

This representation allows us to distinguish between two types of Granger causality; short-run and long-run causality. For example, if we consider equation (2.17), the coefficients of the lagged dynamic regressors can test for short-run causality from variable fundamentals to the exchange rate by testing the null that $\sum_{k=0}^{n2} \eta_{ik} = 0$. While, long-run causality from fundamentals to the exchange rate could be examined by testing the null that the coefficient of the lagged error correction term, $\rho_i = 0$. An equivalent analysis could be done for equation (2.18) testing both the short-run and long-run Granger causality from exchange rates to fundamentals. Results are presented in Table (2.4) below.

In Panel A, the null that $\Delta(fund - fund^*)$ do not Granger cause Δs in the long-run, is rejected in all six countries when performing the multivariate test. In the short-run, this null hypothesis is rejected in all countries but Canada. In the 24 bivariate tests, the null is rejected in 20 instances in the long-run and 10 instances in the short-run. These results provide further support to the monetary model of exchange rate determination, and significantly improve on the comparable findings of the study by Engel and West (2005). They reported short-run causality in only 2 instances in the bivariate equations, and none in the multivariate cases. They, however, do not report results of long-run causality.

Similarly, panel B tests the null that Δs do not Granger cause $\Delta(fund - fund^*)$ in both the long-run and short-run. In the 24 bivariate tests, the null is rejected in only 4 instances in the long-run and 4 instances in the short-run.[22] Our panels A and B of Table (2.4) are directly comparable to panels B and A of Table (2.3) in Engel and West (2005, p.503). Again, if we contrast our results to those of Engel and West (2005), we find that they reported 8 cases where there was short-run causality from the exchange rate to the relevant fundamental bivariate equations, while we only report 4 cases. These findings, along with those from panel A, provide much stronger support to the monetary approach to exchange rate determination.

[22] The null is actually rejected in 6 instances in the long-run. However, 2 of them report a positive t-statistic implying that the coefficient on the lagged error correction term is positive. This means that, in the long-run, it is the fundamental variable that is Granger causing the exchange rate.

Table 2.4: Granger Causality Tests

Panel A. H_0: Fundamentals do not Granger cause Exchange Rate

	Short-run Causality *(H_0: $\sum_{k=0}^{n2} \eta_{ik} = 0$)*						***Long-run Causality*** *(H_0: $\rho_i = 0$)*					
	Canada	***France***	***Germany***	***Italy***	***Japan***	***UK***	***Canada***	***France***	***Germany***	***Italy***	***Japan***	***UK***
multivariate	1.54	43.3***	24.9***	40.9***	12.72**	10.07**	-2.9***	-5.1**	-3.60***	-4.29***	-4.8***	-4.17***
(m-m^*)	.16	4.53	9.86**	2.34	5.51**	6.59**	-1.90*	-2.3**	-1.61	-2.81***	-1.11	-3.07***
(y-y^*)	.93	.32	.11	.69	1.85	.31	-2.38**	-2.1**	-1.88*	-1.91*	-1.96*	-3.19***
(i-i^*)	.25	6.48**	3.96**	7.76***	1.65	2.34	-2.15**	-2.2**	-2.54**	-2.13**	-3.9***	-3.31***
(π-π^*)	6.61*	4.18**	.31	5.41**	4.67**	.13	-1.74*	-1.55	-2.00**	-2.06**	-1.64	-3.01***

Panel B. H_0: Exchange Rate does not Granger cause Fundamentals

	Short-run Causality *(H_0: $\sum_{k=1}^{n1} \omega'_{ik} = 0$)*						***Long-run Causality*** *(H_0: $\rho'_i = 0$)*					
	Canada	***France***	***Germany***	***Italy***	***Japan***	***UK***	***Canada***	***France***	***Germany***	***Italy***	***Japan***	***UK***
multivariate												
(m-m^*)	.16	7.04	1.76	9.22	3.51**	4.99	.46	-.06	-1.43	-2.97***	-1.62	.22
(y-y^*)	.84	1.57	.54	.11	1.47	2.37	-1.44	-.96	-.64	-1.36	1.56	.63
(i-i^*)	.36	11.15**	6.21	6.13	1.71	8.29**	-2.06**	-1.41	-.61	-1.64	-2.27**	-.55
(π-π^*)	.53	2.16	9.06**	.03	1.32	3.89	-1.79*	.29	-.03	1.71*	2.45**	-1.47

*** Significant at the 1% significance level, ** Significant at 5%, * Significant at 10%

Numbers are computed Chi-square-statistics for short-run causality tests, and computed t-statistics for long-run causality tests.

2.4. Conclusion

Numerous studies have attempted to explain the disconnect puzzle between exchange rates and their fundamental determinants. In this paper, we employ a new econometric technique in an attempt to connect some pieces of this puzzle. The contribution of this paper is in the fact that we use the exact same dataset of Engel and West (2005), which is considered a seminal paper in this line of research. Employing the standard Johansen approach to cointegration, Engel and West did not find support for the monetary approach to exchange rate determination. Here, using Pesaran et al's (2001) *ARDL* approach to cointegration, we find evidence of a long-run relationship between exchange rates and fundamentals in all multivariate and most bivariate equations of the same six industrialized countries used by Engel and West. Furthermore, our Granger causality tests report evidence that fundamentals help predict exchange rates in both the short-run and long-run.

These results suggest that, in the long-run, the monetary approach to exchange rate determination does provide a useful explanation of the behavior of exchange rates. The relationship between the exchange rate and its fundamentals are, however, not very clear in the short-run. Thus, in terms of the relevance for policy making, one should only consider the monetary model as a useful benchmark so as to understand the evolution of exchange rate in the long-run. However, it should not be used as a definite tool for fully understanding short-run exchange rate movements, especially in this era of high exchange rate volatility where there is a big possibility that a number of other variables, possibly even unobserved, may come to play in influencing the spot exchange rate.

A future area of research could investigate the forecasting performance of the monetary model using the *ARDL* methodology, possibly using a more updated sample period than the one used in this paper. A number of papers have already investigated the forecasting performance of the monetary model as suggested by their cointegrating equations against that of a simple random walk. Studies of Meese and Rogoff (1983a, 1983b) and Mark (1995) are among the most cited in this area. The two former studies were the first to establish the weak forecasting performance of the monetary model against a naïve random walk model. Mark (1995) revived the monetary approach when he reported evidence of predictability of the exchange rate at longer horizons for four major currencies. These papers first investigate the cointegrating relationship between the variables, and then use that equation to perform their forecasting exercises. It would be noteworthy to re-evaluate the forecasting performance of the monetary model as suggested by the ARDL approach to cointegration against that of the random walk.

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Chapter 3: Exchange Rate Depreciation and the Trade Balance in Egypt

3.1. Introduction

Three concepts within international economics summarize the response of the trade balance to changes in the real exchange rate. The first and most common concept, known as the *Marshal Lerner condition* (ML), asserts that currency depreciation will have a favorable impact on trade balance only if the import and export demand elasticities sum up to more than unity. The other two concepts have to do with the short-run response of the trade balance to a change in a country's exchange rate. More specifically, due to lag structure, a devaluation or depreciation does not have to affect the trade balance immediately. Thus, if the trade balance is deteriorating, it continues to deteriorate until the favorable effects of depreciation emerge. The J- and the S-Curves summarize this response pattern. While the *J-Curve* relies upon a trade balance model and regression analysis, the *S-Curve* adheres to a cross-correlation function. A recent survey by Bahmani-Oskooee and Hegerty (2010) provides a detailed explanation of both curves as well as their application to any country that they have been applied.[23]

A common theme about studies under all three strands of the literature mentioned above is that they fall into three categories. The first employs trade data between one country and rest of the world. The second, in an attempt to remove this aggregation bias,

[23] For a detailed explanation of the J-Curve see Bahmani-Oskooee (1985).

studies the relationship between exchange rate depreciation and international trade at the bilateral level. Indeed, Marquez (1990) concludes that "reliance on multilateral elasticities entails an important loss of information for the questions receiving attention in the literature whereas reliance on bilateral elasticities entails no such loss." Studies in this second group may also suffer from aggregation bias in different commodity flows between two countries may react differently to price changes, hence have different elasticities. Again, this is recognized by Marquez (1990) who recommends strengthening his findings at the bilateral level by disaggregating across commodities. Therefore, the third category of the literature has very recently moved in this direction. In our case, we use industry level bilateral trade data covering the period from 1994Q1 to 2007Q4 disaggregated according to the SITC classification into 59 industries (36 industries) that trade between Egypt-EU (and Egypt-US), respectively. By doing this, we aim at introducing the first comprehensive study in this third category with regards to Egypt.

3.2. ML Condition

Standard textbook in international economics provide mathematical proof that if a devaluation or depreciation is to improve the difference between inpayments and outpayments or the trade balance, sum of export and import demand elasticities must exceed unity, a condition known as the Marshall-Lerner condition (ML hereafter).

3.2.1. Motivation and Literature

Previous studies that estimated the ML condition used aggregate trade data between one country and rest of the world and provided mixed results. For example, Houthakker and

Magee (1969) who estimated the ML condition for 15 developed and 14 developing countries did not find support for the ML condition in most cases. However, Khan (1974) who estimated the condition for only 15 developing countries did find support for the condition in most cases. Both studies were conducted during fixed exchange rate period prior to 1973. The same could be said when we shift to post 1973 period of floating exchange rates. For example, Warner and Kreinin (1983) who considered the experience of 19 industrial countries during both periods concluded that the in most countries the condition is met during the floating exchange rate period. However, when developing countries were considered during floating period by Bahmani-Oskooee (1986), not much support for the ML condition was provided.

It should be mentioned that since the above mentioned studies did not account neither for degree of integration of each variable, nor for cointegration among the variables in their models their results could be considered spurious. For this reason, more recent studies have employed different cointegration techniques and provided support for the ML condition in most countries. Examples include Bahmani-Oskooee (1998), Bahmani-Oskooee and Niroomand (1998), and Bahmani-Oskooee and Kara (2005). Failure to support the ML condition for a given country in any of these studies is said to be due to aggregation bias. To remove the bias, Marquez (1990) and Bahmani-Oskooee and Brooks (1999) concentrate on bilateral trade flows between two countries rather than aggregate trade flows between one country and rest of the world and provide support for the ML condition. In cases the ML condition is not satisfied, Marquez (1990) recommends further disaggregation of bilateral trade flows by commodity. However, not much work has been done at commodity level due to lack of data on commodity prices.

Now that we have come across commodity prices between two countries (US and Egypt), we like to add to the literature on the ML condition by considering the trade flows of 36 industries that trade between the two countries and estimate the price elasticity of export and import demand for each industry to judge the ML condition.[24]

3.2.2. The Model and the Method

A common practice in estimating price elasticities in trade, hence the ML condition is to relate volume of trade to a scale variable measuring economic activity and a relative price term. Since data are reported by Egypt, we specify the import and export demand models from Egypt's perspective. After modifying the models used by Houthakker and Magee (1969) and Bahmani-Oskooee (1986) to conform to commodity level data, we adopt the following specification for Egypt's import of commodity i from the U.S.:

$$\ln M_t^i = \alpha + \beta \ln Y_{EG,t} + \lambda \ln \left(\frac{PM_i}{PD_{EG}}\right)_t + \varepsilon_t \quad (3.2.1)$$

Where M^i is quantity of commodity i imported by Egypt from U.S. As mentioned above, one driving force of imports in any country is the level of economic activity in that country. This, Egypt's real income or output, Y_{EG}, is included in the specification and is expected to exert positive impact on her imports of commodity i. Therefore, an

[24] It should be mentioned that Egypt is not included in any of the studies mentioned above.

estimate of β is expected to be positive. Assuming some degree of substitution between imports and domestically produced goods, import price of commodity i, PM_i relative to domestic price level, PD_{EG}, is included as another determinant. It is expected that an estimate λ to be negative.

Due to symmetry between import and export demand models, we assume U.S. demand for Egypt's export of commodity ii (X^i_t) depends positively on the U.S. income ($Y_{US,t}$) and negatively on Egypt's export price (PX_i) relative to the domestic price level in the U.S. ($PD_{U.S.}$) as in equation (3.2.2):

$$\ln X^i_t = \alpha' + \beta' \ln Y_{US,t} + \lambda' \ln \left(\frac{PX_i}{PD_{US}}\right)_t + \varepsilon'_t \quad (3.2.2)$$

Once (3.2.1) and (3.2.2) are estimated, the ML condition will be met if $|\hat{\lambda}| + |\hat{\lambda}'| > 1$.

Estimates of (3.2.1) and (3.2.2) by any method only yield the long-run income and relative price elasticities. In order to estimate the short-run elasticities and make sure that the variables are converging toward their long-run equilibrium values, we incorporate the short-run dynamics into both specifications and express them as error-correction models. Pesaran *et al*. (2001) offer a unique approach where there is no need for pre-unit-root testing and all short-run and long-run coefficients could be estimated in one step as opposed to two-step procedure of Engle and Granger (1987). The error-correction models following Pesaran et al. (2001) are as follows:

$$\Delta \ln M_t^i = a + \sum_{j=0}^{n} b_j \Delta \ln Y_{EG,t-j} + \sum_{j=0}^{n} c_j \Delta \ln(\frac{PM_i}{PD_{EG}})_{t-j} + \sum_{j=1}^{n} d_j \Delta \ln M_{t-j}^i$$
$$+ \sigma_0 LnM_{t-1}^i + \sigma_1 \ln Y_{EG,t-1} + \sigma_2 \ln(\frac{PM}{PD})_{t-1} + u_t \qquad (3.2.3)$$

And

$$\Delta \ln X_t^i = \mu + \sum_{j=0}^{m} \varphi_j \Delta \ln Y_{US,t-j} + \sum_{j=0}^{m} \psi_j \Delta \ln(\frac{PX_i}{PD_{US}})_{t-j} + \sum_{j=1}^{m} \phi_j \Delta \ln X_{t-j}^i$$
$$+ \theta_0 \ln X_{t-1}^i + \theta_1 \ln Y_{US,t-1} + \theta_2 \ln(\frac{PX_i}{PD_{US}})_{t-1} + v_t \qquad (3.2.4)$$

Without lagged level variables in (3.2.3) and (3.2.4) the two models will be no more than standard VAR models. Pesaran et al. (2001) propose adding the linear combination of lagged level variables as a proxy for lagged error term in Engle-Granger (1987) specification. They then propose using the standard F test to establish their joint significance. If lagged level variables are jointly significant, then they are said to be cointegrated. Although the application of the F test follows standard procedure from the literature, i.e., using the sum of squared residuals from restricted versus unrestricted models, it has new critical values that Pesaran *et al.* (2001) tabulate. A lower bound critical value is provided when all variables in a given model are integrated of order zero or *I(0)*. An upper bound critical value is provided when all variables are integrated of order one or *I(1)*. They then demonstrate that the upper bound could also be used to establish joint significance even if some variables are *I(0)* and some *I(1)*. Since almost all macro variables are either *I(0)* or *I(1)*, there is no need for pre-unit-root testing under this approach.

Models (3.2.3) and (3.2.4) are estimated by applying OLS. The short-run effects are then inferred by the coefficient estimates obtained for the first-differenced variables. The long-run income and price elasticities in (3.2.3) are obtained by the estimates of σ_1 and σ_2 that are normalized on σ_0. By the same token, the long-run income and price in (3.2.4) are calculated by the estimates of θ_1 and θ_2 normalized on θ_0.[25]

3.2.3. The Results

In this section we estimate the two error-correction models using trade flows of 36 industries that trade between Egypt and the U.S. Quarterly data over the period 1994I-2007IV are used to carry out the estimation. Following the literature a maximum of six lags are imposed on each first differenced variable and Akaike's Information Criterion (AIC) is sued to select the optimum lags. The results for each optimum Egypt's import demand model along with diagnostics are reported in Table (3.2.1). Due to the volume of the results we refrain from reporting the short-run coefficient estimates. However, they are available upon request from the authors.

Concentrating on long-run coefficient estimates, we gather that the relative import price term carries its expected negative coefficient in almost all cases. The coefficient is

[25] For details of normalization see Bahmani-Oskooee and Tanku (2008).

significant at least at the 10% level in 27 out of 36 industries, as identified by * above each coefficient. The income elasticity is positive and significant in only six industries coded 03, 05, 12, 22, 55, and 89. It is significant and negative in nine industries coded 17, 26, 29, 33, 65, 74, 75, 77, and 81. These are industries that as Egypt's economy grows they produce more of import-substitute goods and therefore import less of these goods (Bahmani-Oskooee, 1986). These long-run coefficients will not be considered spurious only if we establish cointegration among variables. As the results of the *F test* reveal since our calculated *F statistic* is significant in almost all cases, the variable do have long run relationship.

Table 3.2.1: Empirical Results & Diagnostic Tests – Import Equation

	SITC Description	*cons*	*ln* Y_{EG}	*ln PM*	*F*	ECM_{t-1}	*LM*	*RESET*	*CUSUM (SQ)*	*Adj* R^2
00	**Live animals other than animals of division 03**	20.13**	-.91	-.94***	9.71***	-.73***	3.56	.0009	S (S)	.84
02	**Dairy products and birds' eggs**	20.40	-1.24	-2.99*	2.99**	-.41***	2.77	.27	S (S)	.36
03	**Fish, crustaceans, aquatic invertebrates**	-13.21*	1.92***	-1.41***	10.15***	-.76***	4.36	.21	S (S)	.77
04	**Cereals and cereal preparations**	18.76***	-.26	-1.04***	7.89***	-.91***	4.98	1.58	S (S)	.51
05	**Vegetables and fruit**	7.16***	.15	-1.82***	12.68***	-1.18***	.91	.21	S (S)	.55
06	**Sugars, sugar preparations and honey**	-6.09	.89**	-2.54***	21.77***	-1.18***	5.69	.001	S (S)	.84
07	**Coffee, tea, cocoa, spices, and manufactures thereof**	6.12	.02	-1.75***	16.70***	-1.04***	5.92	.37	S (S)	.63
09	**Miscellaneous edible products and preparations**	18.61***	-.64*	-.78	6.12***	-.52***	1.44	1.43	S (S)	.71
11	**Beverages**	192.60	-7.73	28.92	3.25**	-.04***	4.23	2.91*	S (S)	.48
12	**Tobacco and tobacco manufactures**	3.66	.97***	1.81***	13.82***	-.96***	2.39	1.68	S (S)	.54
22	**Oil-seeds and oleaginous fruits**	-21.59	2.87*	-1.33**	2.91**	-.66***	3.13	.26	S (S)	.81
24	**Cork and wood**	5.74	.46	-1.21***	2.74*	-.36***	4.39	.009	S (S)	.95
26	**Textile fibers and their wastes**	34.59**	-2.03*	-.13	9.46***	-.74***	8.70	.28	S (S)	.37
27	**Crude fertilizers, and crude minerals**	.71	.91***	-.66	15.34***	-.93***	6.50	.13	U (S)	.67
29	**Crude animal and vegetable materials**	18.02***	-.64*	-1.39***	13.34***	-.95***	4.61	.54	S (S)	.71
33	**Petroleum, petroleum products & related materials**	19.08***	-1.02*	-1.74***	12.46***	-.84***	2.53	.39	S (S)	.72
42	**Fixed vegetable fats and oils, crude, refined**	-.07	-.001	-4.61***	2.87**	-.40***	2.13	.72	S (S)	.87
52	**Inorganic Chemicals**	10.08***	.06	-1.02***	9.56***	-.75***	3.75	2.71*	S (S)	.76
54	**Medicinal and pharmaceutical products**	11.46	-.06	.63	2.85**	-.22***	2.80	.02	S (S)	.94
55	**Essential oils & perfume materials; polishing**	-.18	1.03***	-.77**	8.63***	-.74***	1.46	5.1**	S (S)	.83
56	**Fertilizers (other than those of group 27)**	5.39	.25	-1.24***	14.32***	-1.02***	1.03	.87	S (S)	.68
59	**Chemical materials and products**	13.95***	-.09	-.88***	10.58***	-.68***	.75	3.38*	S (S)	.80
61	**Leather, leather manufactures, and dressed furskins**	13.41	-.65	-.71*	2.91**	-.30***	5.16	.10	S (S)	.61
63	**Cork and wood manufactures (excluding furniture)**	6.13	.42	-.98***	9.07***	-.74***	4.25	.91	S (S)	.98
64	**Paper, paperboard and articles of paper pulp**	-.27	.63	-2.65	1.07	-.14*	1.57	1.79	S (S)	.52
65	**Textile yarn, fabrics, made-up articles**	22.84***	-1.08**	-1.33**	5.01***	-.64***	.89	.004	S (S)	.47
66	**Non-metallic mineral manufactures**	10.67***	-.0065	-1.10***	17.64***	-1.05***	4.91	.10	S (S)	.91
67	**Iron and steel**	10.38**	.05	-1.55***	5.40***	-.45***	5.32	.43	S (S)	.64
69	**Manufactures of metals**	15.66***	-.29	-1.32**	2.13	-.40**	2.26	1.77	S (S)	.74
74	**General industrial machinery and equipment**	16.90***	-.26**	-1.37***	9.47***	-.70***	2.46	.11	S (S)	.75
75	**Office machines and automatic data-processing**	9.10***	.35**	-.99***	9.16***	-.72***	4.44	.20	S (S)	.61
77	**Electrical machinery, apparatus & appliances**	19.89***	-.56**	-.78***	7.32***	-.64***	4.82	.06	S (S)	.69

	SITC Description	cons	ln Y_{EG}	ln PM	F	ECM_{t-1}	LM	RESET	CUSUM (SQ)	Adj R^2
81	**Prefabricated buildings; sanitary, plumbing**	21.53***	-1.01*	-.79	3.74**	-.56***	1.24	.14	S (S)	.54
82	**Furniture, and parts thereof; bedding, mattresses**	7.88	.21	-1.21*	4.44***	-.35***	1.49	.99	S (S)	.41
84	**Articles of apparel and clothing accessories**	11.39	-.31	-.34	2.27*	-.49**	9.6**	.10	S (S)	.33
89	**Miscellaneous manufactured articles**	8.92***	.32*	-.81***	8.31***	-.73***	4.83	.06	S (S)	.89

*** Significant at the 1% significance level, ** at 5%, * at 10%

Table 3.2.2: Empirical Results & Diagnostic Tests – Export Equation

	SITC Description	cons	ln Y_{US}	ln PX	F	ECM_{t-1}	LM	RESET	CUSUM (SQ)	Adj R^2
00	**Live animals other than animals of division 03**	-51.2**	3.64***	-.10	3.77**	-.57***	2.21	.005	S (S)	.66
02	**Dairy products and birds' eggs**	-34.11	2.40	-2.42	4.20**	-.46***	4.51	.02	S (S)	.55
03	**Fish, crustaceans, aquatic invertebrates**	1.25	.11	-1.94***	7.67***	-.55***	2.99	.006	S (S)	.39
04	**Cereals and cereal preparations**	-126.4*	8.32***	-.60	11.93***	-.77***	11.5**	2.03	S (S)	.63
05	**Vegetables and fruit**	-32.1**	2.65***	-.81*	7.17***	-.62***	2.79	.09	S (S)	.55
06	**Sugars, sugar preparations and honey**	-78.8**	5.44***	-.39*	23.56***	-1.21***	3.13	.37	S (S)	.64
07	**Coffee, tea, cocoa, spices, and manufactures**	44.6**	-1.87**	.41	13.95***	-1.12***	7.81*	.05	S (S)	.49
09	**Miscellaneous edible products and preps**	-43.7**	3.37***	.34	19.75***	-1.11***	3.83	4.57**	S (S)	.61
11	**Beverages**	-17.56	1.66	-.03	6.84***	-.63***	3.29	.36	S (S)	.25
12	**Tobacco and tobacco manufactures**	38.31	-2.09	-1.50	2.96**	-.36***	4.97	15.8**	S (S)	.27
22	**Oil-seeds and oleaginous fruits**	.94	.44	-.58	7.72***	-.62***	2.96	1.02	S (U)	.30
24	**Cork and wood**	-77.98	5.26***	-.55***	14.01***	-.90***	1.63	.10	S (S)	.46
26	**Textile fibers and their wastes**	.27	1.36	1.36	1.92	-.31**	5.55	1.57	U (S)	.46
27	**Crude fertilizers, and crude minerals**	-89.9**	6.12***	-1.41***	9.20***	-.77***	6.76	5.93	S (U)	.94
29	**Crude animal and vegetable materials**	21.1**	-.49*	-.13	18.03***	-1.25***	.67	1.69	S (S)	.61
33	**Petroleum, petroleum products**	-47.46	3.36	-2.42***	16.34***	-1.01***	1.20	.06	S (U)	.58
42	**Fixed vegetable fats and oils, crude**	-75.0**	5.09***	-.80***	10.99***	-.79***	2.12	.22	S (S)	.44
52	**Inorganic Chemicals**	86.75	-4.91	-1.26*	3.63**	-.33***	5.13	.54	S (S)	.52
54	**Medicinal and pharmaceutical products**	-10.65	1.04	-.44***	14.24***	-.91***	4.63	5.72**	S (S)	.51
55	**Essential oils & perfume materials; polishing**	6.05	.23	-1.29***	13.96***	-.83***	2.53	3.19*	S (S)	.87
56	**Fertilizers (other than those of group 27)**	-34.75	2.75*	-1.37***	9.22***	-.82***	1.16	8.22**	S (U)	.40
59	**Chemical materials and products**	29.98	-1.60	-1.89***	17.30***	-1.01***	1.21	.04	S (U)	.50
61	**Leather, leather manufactures**	2.37	.21	-.54***	15.13***	-.96***	1.28	6.57	S (S)	.54

	SITC Description	*cons*	*ln Y_{US}*	*ln PX*	*F*	*ECM_{t-1}*	*LM*	*RESET*	*CUSUM (SQ)*	*Adj R^2*
63	**Cork and wood manufactures**	62.6**	-3.57**	-1.01***	16.94***	-.97***	4.42	.95	S (S)	.60
64	**Paper, paperboard and articles of paper pulp**	41.2**	-2.11*	-.59**	14.06***	-.91***	2.64	.02	S (S)	.48
65	**Textile yarn, fabrics, made-up articles**	20.34*	-.47	-1.49***	4.42***	-.33***	9.17*	.19	S (S)	.93
66	**Non-metallic mineral manufactures**	-47.4**	3.29**	-1.51***	10.26***	-.67***	3.53	1.64	S (S)	.64
67	**Iron and steel**	-82.82	5.09	-4.20	2.76*	-.27***	1.51	1.29	S (U)	.47
69	**Manufactures of metals**	-5.08	.85*	-1.45***	18.58***	-.90***	5.17	.89	S (S)	.79
74	**General industrial machinery and equipment**	10.66	-.24	-.62***	13.26***	-.88***	6.47	.30	S (S)	.55
75	**Office machines and automatic data-processing**	21.88	-1.02	-.88***	13.28***	-.82***	4.61	.04	S (S)	.62
77	**Electrical machinery, apparatus & appliances**	-.75	.46	-.90***	11.42***	-.82***	.80	4.76	S (S)	.50
81	**Prefabricated buildings; sanitary, plumbing**	-2.28	.62	-.80**	6.33***	-.48***	2.54	2.91*	S (S)	.69
82	**Furniture, and parts thereof; bedding**	-12.2**	1.39***	-1.11***	21.78***	-.93***	10.3**	4.94**	S (U)	.86
84	**Articles of apparel and clothing accessories**	31.1**	-1.05**	-.94***	9.84***	-.76***	14.4**	.36	S (S)	.97
89	**Miscellaneous manufactured articles**	1.42	.54	-.24**	29.08***	-1.26***	4.32	2.60	S (S)	.66

*** Significant at the 1% significance level, ** at 5%, * at 10%

Table 3.2.3: Effect of Exchange Rate Depreciation on Trade Balance in Egypt

code	*SITC Description*	*Trade Share*	|*PM*|+|*PX*|	*ML*
00	**Live animals other than animals of division 03**	**0.05%**	0.94	
02	**Dairy products and birds' eggs**	**0.46%**	2.99	Yes
03	**Fish, crustaceans, aquatic invertebrates and preparations thereof**	**0.12%**	3.35	Yes
04	**Cereals and cereal preparations**	**43.06%**	1.04	Yes
05	**Vegetables and fruit**	**0.40%**	2.63	Yes
06	**Sugars, sugar preparations and honey**	**0.06%**	2.93	Yes
07	**Coffee, tea, cocoa, spices, and manufactures thereof**	**0.04%**	1.75	Yes
09	**Miscellaneous edible products and preparations**	**0.09%**	0	
11	**Beverages**	**0.002%**	0	
12	**Tobacco and tobacco manufactures**	**0.25%**	1.81	Yes
22	**Oil-seeds and oleaginous fruits**	**7.20%**	1.33	Yes
24	**Cork and wood**	**0.27%**	1.76	Yes
26	**Textile fibers and their wastes (not manufactured into yarn or fabric)**	**0.21%**	0	
27	**Crude fertilizers, and crude minerals (excluding coal and petroleum)**	**0.22%**	1.41	Yes

code	***SITC Description***	***Trade Share***	$\lvert PM\rvert+\lvert PX\rvert$	***ML***
29	**Crude animal and vegetable materials**	**0.18%**	1.39	Yes
33	**Petroleum, petroleum products and related materials**	**5.45%**	4.16	Yes
42	**Fixed vegetable fats and oils, crude, refined or fractionated**	**0.05%**	5.41	Yes
52	**Inorganic Chemicals**	**0.11%**	2.28	Yes
54	**Medicinal and pharmaceutical products**	**1.05%**	0.44	
55	**Essential oils & perfume materials; polishing & cleansing preparations**	**0.20%**	2.06	Yes
56	**Fertilizers (other than those of group 27)**	**0.85%**	2.61	Yes
59	**Chemical materials and products**	**0.82%**	2.77	Yes
61	**Leather, leather manufactures, and dressed furskins**	**0.001%**	1.25	Yes
63	**Cork and wood manufactures (excluding furniture)**	**0.10%**	1.99	Yes
64	**Paper, paperboard and articles of paper pulp**	**0.67%**	0.59	
65	**Textile yarn, fabrics, made-up articles, and related products**	**0.99%**	2.82	Yes
66	**Non-metallic mineral manufactures**	**0.40%**	2.61	Yes
67	**Iron and steel**	**0.24%**	1.55	Yes
69	**Manufactures of metals**	**0.97%**	2.77	Yes
74	**General industrial machinery and equipment, and machine parts**	**3.49%**	1.99	Yes
75	**Office machines and automatic data-processing machines**	**0.86%**	1.87	Yes
77	**Electrical machinery, apparatus & appliances and electrical parts**	**1.10%**	1.68	Yes
81	**Prefabricated buildings; sanitary, plumbing, and heating**	**0.04%**	0.8	
82	**Furniture, and parts thereof; bedding, mattresses & mattress supports**	**0.44%**	2.32	Yes
84	**Articles of apparel and clothing accessories**	**1.32%**	0.94	
89	**Miscellaneous manufactured articles**	**0.93%**	1.05	Yes

Trade shares are for 2007Q4

Only statistically significant coefficients are used to calculate $\lvert PM\rvert+\lvert PX\rvert$

Several other diagnostic statistics are also reported in Table (3.2.1). Using the long-run coefficient estimates and long-run import demand model (3.2.1) we calculated the error-term and lag it by one period. Calling this lagged error-correction term, ECM_{t-1}, we then replace the linear combination of lagged level variables in (3.2.3) by ECM_{t-1} and estimate each model after imposing the optimum lags. If adjustment of variables is to be toward their long-run values, we expect ECM_{t-1} to carry a significantly negative coefficient which is indeed the case from the results in Table (3.2.2). Reported in Table (3.2.2) is also the Lagrange Multiplier (LM) statistics which is sued to test serial correlation among the residuals. It is distributed as χ^2 with four degrees of freedom since data are quarterly. Given its critical value of 9.48, only in the results for industry coded 84, the residuals suffer from serial correlation. Ramsey's RESET test which is also distributed as χ^2 but with one degree of freedom is also reported. This statistic is used to judge misspecification of each optimum model. Given its critical values of 3.84, it is significant only in the case of industry 55. Thus, except industry coded 55, all other optimum models are correctly specified. To test for stability of all coefficients (i.e., short run as well as long run estimates) following the literature we apply Brown et al.'s (1975) CUSUM and CUSUMSQ tests to the residuals of each optimum model. While stable estimates are identified by "S", unstable ones are identified by "U". Clearly all estimates are stable.[26] Finally, adjusted R^2 is also reported to reflect on goodness of fit in each optimum model.

Following the same procedure, we turn to estimates of Egypt's export demand model of each industry and again report results similar to Table (3.2.1) in Table (3.2.2).

[26] For graphical presentation of these tests see Bahmani-Oskooee et al. (2005).

Clearly, the relative price term carries a negative and significant coefficient in 25 out of 36 industries. Thus, it appears that Egypt can boost its export of these goods by devaluation or cutting export prices. The U.S. income elasticity of significantly positive in 12 industries and it is significantly negative in five industries coded 07, 29, 63, 64, and 84. Once again, as the U.S. economy grows, U.S. produces more of import substitute goods and imports less of these goods.

Again, our long-run analysis is only valid if we establish cointegration in any optimum model that either income or relative price term carried a significant coefficient. The results of the *F test* indeed supports cointegration in every model in which there was at least one significant coefficient. The ECM_{t-1} carries a significantly negative coefficient in all models signifying importance of adjustment toward long run. Again, residuals in most models are autocorrelation free as judged by the *LM statistic*. Reflected by the *RESET statistic*, most optimum models are correctly specified and do not suffer from any structural break (per results of CUSUM and CUSUMSQ tests). Finally, *adjusted* R^2 reflects a good fit in most models.

We are now in a position to combine results from Tables (3.2.1) and (3.2.2) and infer the sum of absolute value of price elasticities so that we can judge the Marshall-Lerner condition. Note that we only consider the price elasticities that are negative and significant. The sum is reported inn Table (3.2.3). We also report trade share of each industry to determine whether industry size plays any role.

It is clear from Table (3.2.3) that the ML condition is met in 28 out of 36 cases, implying that depreciation of Egyptian pound against the U.S. dollar will improve the trade balance of these 28 industries in the long run. All large industries, i.e., industries coded 04 (with 43 % share of the market), 22 (with 7.20 % of market share), 33 (with 5.45 % market share), and 74 (with 3.49 % market share) will benefit from currency depreciation. These four industries possess almost 60% of market share. All in all, since the ML condition is satisfied in most industries, Egypt can devalue its currency and enjoy an improvement in its overall trade balance with the U.S. in the long run.

3.2.4. Summary and Conclusion

Currency devaluation under the fixed exchange rate system or depreciation under the floating rate system is said to improve a country's trade balance in the long run if sum of absolute value of import and export demand elasticities exceed unit. This condition is known as the Marshall-Lerner condition which traditionally tested for many countries. In testing the Marshall-Lerner condition, however, researchers have used trade flows of one country with the rest of the world. Since constructing a price index for the rest of the world as well as measuring the rest of the world income embodies error and omission, such studies are said to suffer from aggregation bias. To remove the bias, a few studies have concentrated on using trade data at bilateral level between two countries. However, they have also proxied import and export prices since these prices do not exist between two countries for their bilateral but aggregate trade flows.

These studies at bilateral level suffer from another aggregation bias in that different commodities react differently to exchange rate changes and significant effect in one industry could be offset by an insignificant effect in another industry yielding an overall insignificant outcome. To remove the bias in this second group, one needs to concentrate on commodity level data and estimate the ML condition at commodity or industry level.

Since commodity prices are rarely available internationally, no study has attempted to test the ML condition at commodity level. Now that we have come across export and import prices for 36 industries that trade between Egypt and the U.S., we break into the literature by estimating the price elasticities, hence the ML condition at commodity level. Using quarterly data over the period 1994-2007 and bounds testing approach to cointegration and error-correction modeling, the results revealed that the ML condition was met in 28 our of 38 industries. Included among these industries there were small as well as the large industries. More specifically, the condition was satisfied in four largest industries that account for almost 60% of the market. These were: Cereal and cereal preparations; Oil-seeds and oleaginous fruits; Petroleum, petroleum products and related materials; and General industry machinery and equipment. Since the condition was satisfied in most industries, Egypt can enjoy an improvement in her overall trade balance with the U.S. in the long run due to devaluation of Egyptian pound.

3.3. J-curve

3.3.1. Motivation and Literature

The J-Curve has been tested for Egypt in a number of studies. Bahmani-Oskooee and Malixi (1992) employed a trade balance model which included domestic income and money supply, world income and money supply, and the real exchange rate as determinants of the trade balance. The model was tested for 13 developing countries, including Egypt. While no support for the J-Curve was found in the short run, currency depreciation seemed to have significant favorable long-run effects on the trade balance of Egypt with the rest of the world. These findings could be considered spurious since Bahmani-Oskooee and Malixi (1992) did not account for the integrating properties of the variables involved. Indeed, when Bahmani-Oskooee and Alse (1994) tested for integrating properties of the trade balance and the real exchange rate of 42 countries, the two variables were integrated of different orders in the case of Egypt. Hence, cointegration analysis could not be applied. However, when the data was extended and additional variables included in the trade balance model, Bahmani-Oskooee (2001) who applied Engle-Granger and Johansen cointegration methods found that indeed, in the case of Egypt the variables are cointegrated and currency depreciation or devaluation has favorable effects on Egypt's trade balance with the rest of the world. There was no attempt to test the J-curve using the error-correction modeling approach.[27] Baharumshah and Yol (2005) fill this gap by estimating an error-correction model for Egypt, Morocco, and Tunisia. In each case, they actually estimate bilateral models between each country

[27] Note that the real effective exchange rate constructed for Egypt showed considerable depreciation of the Egyptian pound over the period 1971-1994. The same was true when El-Ramly (2008) plotted the index over the period 1982-2004.

and the U.S. first and between each country along with Japan. The J-Curve phenomenon received support in the results for the Egypt-Japan trade balance but not in the results for the Egypt-U.S. trade balance. Similarly, the long-run results revealed that the real exchange rate had significantly favorable effects on the bilateral trade balance between Egypt and Japan, but not on the trade balance between Egypt and the U.S. These findings should be viewed with caution since the exchange rate used in the bilateral trade balance model was the real effective rate and not the real bilateral exchange rate.

Estimating a trade balance model using bilateral trade data has more appeal than estimating a trade balance model using aggregate trade data between one country and the rest of the world, because it reduces the degree of aggregation. Since the introduction of the euro and the formation of the euro zone, the relative strength of Egypt’s trading partners have shifted more in favor of the euro zone. In recent years 50% of Egypt’s trade belongs to EU countries, Arab countries, and the U.S. combined. Among these three entities, EU alone has about a 25% share of trade, making it the largest trade partner. Therefore, in this study, we concentrate on the trade between Egypt and the EU and investigate the short-run and the long-run effects of real depreciation of the Egyptian pound against the euro on the bilateral trade balance between the two regions. Suspecting that the trade between the two regions could yet suffer from another aggregation bias, we disaggregate the trade data between the two regions by commodity and estimate a bilateral trade balance model for each of the 59 industries that trade between the two regions. These 59 industries engage in almost 100% of the trade between Egypt and the

EU, as reflected by their trade shares. Data definition and sources appear in the Appendix.

3.3.2. The Model and the Method

A method for testing the J-Curve phenomenon was originally introduced by Bahmani-Oskooee (1985) when he introduced a reduced form trade balance model. The phenomenon was tested by imposing a lag structure on the real exchange rate as a main determinant. Since the introduction of cointegration and error-correction modeling techniques, emphasis has shifted to dealing with the integrating properties of the variables involved. This has necessitated the application of error-correction techniques to test the short-run effects of depreciation, i.e., the J-Curve concept and cointegration method which is designed to capture the long-run effects of depreciation on the trade balance. Since these methods rely upon a reduced form model, we begin with a reduced form trade balance model from the literature outlined by specification (3.3.1):[28]

$$\text{Log}\, TB_t^i = \alpha + \beta\, \text{Log}\, Y_{EG,t} + \gamma\, \text{Log} Y_{EU,t} + \lambda\, \text{Log}\, REX_t + \varepsilon_t \quad (3.3.1)$$

where TB^i is a measure of the trade balance of industry i. Since the model is log linear, following the literature, the trade balance is defined as the ratio of Egypt's export of industry i to the EU over Egypt's imports of industry i from the EU.[29] Three variables are considered to be main determinants of the trade balance. Egypt's and the EU level of

[28] For application of this model for other countries, see the review article by Bahmani-Oskooee and Hegerty (2010).
[29] This measure is also said to be in real or nominal terms. For more details see Bahmani-Oskooee (1991).

economic activities, denoted by Y_{EG} and Y_{EU} respectively, as well as the real exchange rate between the Egyptian pound and the euro. Since an increase in Egypt's economic activity is expected to increase her imports of industry i, we expect an estimate of β to be negative. On the other hand, since an increase in the level of economic activity in the EU is expected to lead to an increase in Egypt's exports of industry i, an estimate of γ is expected to be positive. As for the effects of the real exchange rate, the estimate of λ is expected to be positive given the construction of the real exchange rate. More precisely, an increase in REX reflects a real depreciation Egyptian pound (see Appendix for details).

The trade balance model identified by (3.3.1) is basically a long-run model and the coefficient estimates yields long-run estimates. These long-run estimates cannot be used to test the J-Curve since the J-Curve is a short-run phenomenon. To test the J-Curve, we must incorporate the short-run dynamics into (3.3.1) via error-correction modeling. Thus, following Pesaran *et al.* (2001) and the bounds testing approach we rely upon the following specification:

$$\Delta \text{Log TB}^{i}_{t} = \alpha + \sum_{K=1}^{n1} \omega_K \Delta \text{Log TB}^{i}_{t\text{-}k} + \sum_{k=0}^{n2} \beta_k \Delta \text{ Log Y}_{EG,t-k} + \sum_{k=0}^{n3} \gamma_k \Delta \text{ Log Y}_{EU,t-k} + \sum_{k=0}^{n4} \lambda_k \Delta \text{ Log REX}_{t-k}$$

$$+ \delta_1 \text{Log TB}^{i}_{t\text{-}1} + \delta_2 \text{Log Y}_{EG,t\text{-}1} + \delta_3 \text{ Log Y}_{EU,t-1} + \delta_4 \text{ Log REX}_{t-1} + u_t \qquad (3.3.2)$$

Pesaran *et al*. (2001) demonstrate that one can establish cointegration or a long-run relationship among the variables by establishing joint significance of lagged level variables. They propose using the familiar *F test* with new critical values that they tabulate. An upper bound critical value is provided when all variables in a given model are assumed to be integrated of order one. A lower bound is provided by assuming all variables are integrated of order zero or stationary. For cointegration, the *calculated F statistic* must be greater than the upper bound. The most appealing property of this approach is the demonstration by Pesaran *et al.* (2001) that their critical value is also valid even if some variables are integrated of order one and some integrated of order zero, ruling out pre-unit root testing. Another advantage of specification (3.3.2) is that the short-run and the long-run effects are estimated in one step. More precisely, once (3.3.2) is estimated, the short-run effects are reflected by the coefficient estimates of the first-differenced variables. For example, the short-run effects of real depreciation are judged by the estimates of λ_k's. Negative values for initial k's followed by positive values for subsequent k's will support the J-Curve. The long-run effects of depreciation, however, are judged by the size and significance of δ_4 normalized on δ_1. The same normalization applies to other variables as well.[30] We estimate the error-correction model in (3.3.2) in the next section.[31]

3.3.3. The Results

In this section we try to estimate the error-correction model (3.3.2) first using the aggregate bilateral trade data between Egypt and the EU. Suspecting that the results could suffer from aggregation bias, we disaggregate the trade data by commodity and estimate

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[30] For more details of normalization, see Bahmani-Oskooee and Tanku (2008).
[31] For other applications of this approach see Payne (2003), Tang (2007), Mohammadi et al. (2008) and De Vita and Kyaw (2008).

the model for 59 industries that traded between Egypt and the EU. The first strategy in estimating (3.3.2) is the order of the lags. Previous research (e.g., Halicioglu 2007) has shown that the results could be sensitive to lags order. Hence, others like Bahmani-Oskooee and Hegerty (2009) have recommended and employed a set criterion to select the optimum lags. Following the literature, we use Akaike's Information Criterion (AIC) to select the lag order. Since the data are quarterly over the period 1994I-2007IV, a maximum of six lags are imposed on each variable and AIC is used to select the optimum lags. Therefore, throughout the study, results belong to each optimum model. Furthermore, due to the volume of the results, we report them in three tables and discuss them one by one.

Since our concern is the short-run response of the trade balance to changes in the real exchange rate, in Table (3.3.1), we report the short-run coefficient estimates only for the real exchange rate. From the results that belong to the aggregate trade model reported in the first row and labeled "TOTAL" we gather that a positive coefficient is followed by negative coefficients and then again by positive ones, violating the J-Curve hypothesis. The same is true when we consider the coefficient estimates that belong to each industry. Like previous research, there is no specific pattern. However, there are 36 industries for which there is at least one significant coefficient estimate. These significant coefficients are identified by one, two, or three *. These results imply that in 36 industries a real depreciation of the Egyptian pound has short-run effects on these industries' trade balances. Thus, the short-run significant effects found in the aggregate bilateral results should be attributed to trade by these 36 industries that are coded as: 0, 3, 4, 5, 6, 8, 9, 26, 27, 28, 32, 33, 34, 42, 43, 52, 56, 57, 58, 59, 61, 64, 65, 67, 69, 71, 72, 73, 74, 76, 77, 78, 79, 82, 83, 88, and 89. A major question now is whether these short-run significant effects last in the long run? To this end, we consider the long-run estimates reported in Table (3.3.2).

Table 3.3.1: Short Run Coefficients of the Real Exchange Rate.

code	*SITC Description*	$\Delta ln\ REX_t$		$\Delta ln\ REX_{t-1}$		$\Delta ln\ REX_{t-2}$		$\Delta ln\ REX_{t-3}$		$\Delta ln\ REX_{t-4}$	
	TOTAL	3.25	(2.22)	-1.85	(2.29)	-6.40	(2.28)***	-2.25	(2.41)	2.31	(2.27)
0	Live Animals other than Animals of Division 03	-2.62	(3.37)	3.40	(3.82)	-7.99	(-3.33)**	..		..	
1	Meat And Meat Preparations	2.52	(2.95)	..		..		..		..	
2	Dairy Products , Birds Eggs	0.59	(3.02)	..		..		..		..	
3	Fish Crustaceans, Molluscs, Aquatic Invert.	3.26	(1.27)**	0.08	(1.40)	2.07	(1.28)	-6.30	(1.29)***	-3.10	(1.42)**
4	Cereals ,Cereal Preparations	4.72	(2.89)	-5.50	(3.12)*	-5.02	(2.98)	..		..	
5	Vegetables , Fruit	2.37	(1.57)	-4.28	(1.54)***	..		..		..	
6	Sugars, Sugar Preparations, Honey	12.64	(3.45)***	..		..		..		..	
7	Coffee.Tea,Cocoa,Spices , Manufs.Thereof.	-0.74	(1.12)	..		..		..		..	
8	Feeding Stuff For Animals	-2.90	(3.99)	-10.47	(4.06)**	-14.88	(4.33)***	-3.39	(4.45)	-0.92	(4.14)
9	Miscellaneous Edible Prod and Preparations	5.24	(2.28)**	-4.12	(2.23)*	..		..		..	
11	Beverages	-2.14	(3.68)	..		..		..		..	
12	Tobacco , Tobacco Manufactures	1.20	(2.51)	..		..		..		..	
22	Oil Seeds , Oleaginous Fruits	6.03	(4.09)	..		..		..		..	
23	Crude Rubber	0.41	(2.67)	..		..		..		..	
24	Cork , Wood	1.38	(1.85)	..		..		..		..	
26	Textile Fibres , Their Wastes	3.74	(2.00)*	0.14	(2.28)	7.04	(2.14)***	-3.23	(2.25)	4.38	(2.20)*
27	Crude Fertilizers And Crude Minerals	3.08	(1.38)**	..		..		..		..	
28	Matalliferous Ores , Metal Scrap	-5.76	(2.78)**	77996	(2.88)	-2.79	(2.75)	6.30	(2.86)**	5.20	(2.93)*
29	Crude Matl.Animal Or Veg.Orign. N.E.S	0.39	(0.99)	..		..		..		..	
32	Coal, Coke , Briquettes	9.83	(4.81)**	..		..		..		..	
33	Petroleum,Petboleum Products	5.00	(1.98)**	..		..		..		..	
34	Gas, Natural, Manufactured	6.00	(3.87)	9.31	(4.12)**	-13.52	(4.12)***	..		..	
42	Fixed Veg. Fats , Oils Crude Pefined	5.01	(5.03)	0.78	(4.97)	12.75	(5.00)**	-10.58	(5.14)**	..	
43	Animal Or Veg.Fats, Oils Processed	0.21	(2.57)	0.01	(2.69)	-5.30	(2.56)**	-0.40	(2.55)	-6.93	(2.57)***
51	Organic Chemicals	2.04	(3.11)	..		..		..		..	
52	Inorganic Chemicals	0.45	(1.38)	3.39	(1.49)**	2.58	(1.53)*	5.59	(1.67)***	..	
53	Dyeing,Tanning, Colouring Materials	3.62	(4.21)	..		..		..		..	
54	Medicinal, Pharmace Utical Products	-0.76	(1.54)	..		..		..		..	
55	Essential Oils,Pesinoids,Plshng.,Cleang.Preps.	-1.22	(0.84)	..		..		..		..	
56	Fertilizers	6.60	(3.41)*	-0.38	(3.88)	11.69	(3.70)***	-2.78	(3.85)	-4.87	(3.55)
57	Plastics In Primary Forms	7.54	(3.83)*	..		..		..		..	
58	Plastics In Non-Primary Forms	3.38	(3.84)	-2.29	(3.99)	-11.95	(3.80)***	..		..	

code	*SITC Description*	$\Delta ln\ REX_t$		$\Delta ln\ REX_{t-1}$		$\Delta ln\ REX_{t-2}$		$\Delta ln\ REX_{t-3}$		$\Delta ln\ REX_{t-4}$	
59	Chemical Materials , Products , N.E.S.	1.75	(1.94)	-0.08	(1.95)	-5.04	(1.96)**	0.74	(1.96)	-5.44	(1.94)***
61	Leather,Leather Manfacture,N.E.S	1.99	(2.37)	-1.03	(2.23)	7.35	(2.16)***	2.84	(2.24)	-4.12	(2.08)*
62	Rubber Manufactures	0.90	(3.01)	..		..		..		..	
63	Cork , Wood Manufactures (Excluding Furniture)	-0.71	(2.22)	..		..		..		..	
64	Paper,Paperboard,,Articles Of Paper Pulp	-4.26	(3.16)	8.74	(3.16)***	-8.00	(3.19)**	5.49	(3.13)*	..	
65	Textile Yarn Fabrics Made-Up Art	1.59	(0.67)**	0.28	(0.71)	0.02	(0.69)	-1.95	(0.68)***	1.80	(0.68)**
66	Non-Metalic Mineral Mnfctrs,N.E.S.	2.01	(1.32)	..		..		..		..	
67	Iron And Steel	4.00	(1.49)**	3.98	(1.40)	-0.73	(1.47)	-1.45	(1.47)	-1.69	(1.40)
68	Non-Ferrous Metals	0.69	(1.05)	..		..		..		..	
69	Manufactures Of Metals Nes	1.01	(1.34)	-1.82	(1.44)	-0.72	(1.41)	-2.74	(1.3945)*	-4.13	(1.42)***
71	Power Generating Machinery And Equipment	8.12	(5.23)	5.26	(5.52)	0.15	(5.18)	-3.38	(5.32)	12.62	(5.08)*
72	Mch. Industries	7.56	(3.61)**	..		..		..		..	
73	Netal Working Mchy.	-3.29	(4.53)	1.30	(4.59)	-2.66	(4.57)	-11.68	(4.80)**	..	
74	General Indus. Machinery, Equip.,Mach.	1.96	(1.41)	2.22	(1.45)	3.28	(1.41)**	2.99	(1.47)**	..	
75	Office Mch. , Automatic Data Procg	5.89	(3.50)	..		..		..		..	
76	Telecom,Sound Record,Reproduc.Apprts.,Equp.	-5.84	(5.12)	1.07	(5.47)	-10.00	(5.03)*	..		..	
77	Elecl.Mchy,Apprt., Appl.,Parts Thereof	-0.21	(2.16)	-2.06	(2.22)	0.45	(2.13)	-1.35	(2.34)	-2.02	(2.09)
78	Road Vehicles (Including Air-Cushion Vehicles)	-1.64	(3.84)	1.62	(3.69)	-9.85	(3.64)**	..		..	
79	Other Transport Equp	-13.42	(4.50)***	..		..		..		..	
81	Prefabricated-Buildings-Sanitsary Plumbing	-0.62	(1.64)	..		..		..		..	
82	Furniture And Parts Thereof; Bedding	3.33	(0.79)***	0.81	(0.90)	-0.62	(0.87)	0.05	(0.86)	-1.39	(0.86)
83	Travel Goods Handbags And Similar Containers	-0.23	(3.78)	7.06	(4.09)*	-6.19	(3.96)	10.11	(3.90)**	-7.37	(3.77)*
84	Articles Of Apparel And Clothing Accessories	-0.75	(1.31)	..		..		..		..	
85	Footwear	4.57	(3.34)	..		..		..		..	
87	Professional, Scientific, Controlling Instuments	1.79	(3.41)	..		..		..		..	
88	Photographic App. N.E.S. Clocks , Watches	0.66	(4.12)	7.37	(4.51)	11.82	(4.61)**	-14.37	(4.46)***	-5.31	(4.70)
89	Miscellaneous, Manufactured Articles N.E,.S.	-1.22	(1.51)	-1.26	(1.57)	3.7115	(1.49)**	..		..	

Standard errors are in parenthesis
*** Significant at the 1% significance level
** Significant at the 5% significance level
* Significant at the 10% significance level

Table 3.3.2: Long Run Coefficient Estimates

code	*SITC Description*	*constant*		*ln Y_{EU}*		*ln Y_{EG}*		*ln REX*	
	TOTAL	-77.30	(17.97)***	6.25	(1.81)***	-1.57	(0.86)*	1.48	(0.30)***
0	Live Animals Other Than Animals of division03 (0.04%)	-300.65	(-190.98)	29.80	(-21.16)	-13.19	(-11.07)	6.94	(2.63)**
1	Meat And Meat Preparations (0.02%)	-493.36	(236.26)**	39.49	(23.21)*	-8.35	(-10.50)	1.81	(3.39)
2	Dairy Products , Birds Eggs (0.29%)	-740.29	(113.69)***	76.72	(12.60)***	-35.87	(-6.55)***	9.16	(1.35)***
3	Fish Crustaceans, Mollusc, Aquatic invertebrates (0.86%)	167.89	(61.32)**	-17.11	(7.09)**	6.80	(3.92)*	0.72	(1.04)
4	Cereals ,Cereal Preparations (1.99%)	-137.68	(47.55)***	10.80	(5.33)*	-2.37	(-2.92)	1.93	(0.75)**
5	Vegetables , Fruit (4.04%)	80.03	(24.59)***	-7.64	(2.56)***	2.91	(1.25)**	-0.35	(0.33)
6	Sugars, Sugar Preparations, Honey (0.16%)	-721.05	(83.17)***	69.51	(9.18)***	-27.47	(4.76)***	7.85	(0.99)***
7	Coffee. Tea, Cocoa, Spices, Manufs. Thereof. (0.13%)	27.84	(-34.13)	-2.88	(-3.83)	1.20	(-2.1)	-0.71	(0.56)
8	Feeding Stuff For Animals (0.13%)	98.02	(-58.26)	-12.82	(6.47)*	7.51	(3.49)**	0.06	(1.09)
9	Miscellaneous Edible Prod and Preparations (0.52%)	-97.12	(-77.38)	8.62	(-8.54)	-3.53	(-4.59)	3.69	(1.17)***
11	Beverages (0.02%)	-369.37	(122.47)***	35.52	(13.82)**	-14.23	(7.41)*	5.58	(1.58)***
12	Tobacco , Tobacco Manufactures (0.38%)	-172.38	(42.70)***	9.85	(4.31)**	1.66	(-2.11)	0.16	(0.76)
22	Oil Seeds , Oleaginous Fruits (0.05%)	96.27	(-89.59)	-9.36	(-9.14)	3.33	(-4.53)	2.24	(1.62)
23	Crude Rubber (0.13%)	-97.82	(-89.58)	4.46	(-9.11)	1.91	(-4.54)	2.50	(1.66)
24	Cork , Wood (2.26%)	19.82	(-28.89)	-5.29	(3.13)*	4.50	(1.65)***	0.29	(0.48)
26	Textile Fibres , Their Wastes (0.47%)	-73.99	(25.13)***	6.60	(2.54)**	-1.71	(-1.22)	-1.99	(0.45)***
27	Crude Fertilizers And Crude Minerals (0.49%)	-199.40	(26.79)***	18.63	(3.07)***	-6.92	(1.67)***	2.86	(0.32)***
28	Matalliferous Ores , Metal Scrap (1.26%)	11.13	(-45.01)	-1.03	(-4.56)	0.64	(-2.2)	-3.52	(0.89)***
29	Crude Matl.Animal Or Veg.Orign. N.E.S (0.25%)	44.52	(-28.44)	-4.04	(-3.18)	1.31	(-1.69)	0.11	(0.35)
32	Coal, Coke , Briquettes (0.27%)	-139.13	(-118.05)	11.02	(-11.86)	-2.40	(-5.59)	3.63	(1.87)*
33	Petroleum, Petrol. products & related materials (18.19%)	59.58	(32.24)*	-4.60	(-3.25)	0.73	(-1.60)	1.50	(0.58)**
34	Gas, Natural, Manufactured (14.09%)	-116.57	(48.07)**	10.74	(5.13)**	-4.37	(-2.60)	6.52	(0.73)***
42	Fixed Veg. Fats , Oils Crude Pefined Or Fraction. (0.03%)	-68.69	(-100.71)	0.97	(-10.15)	3.54	(-4.84)	5.63	(1.60)***
43	Animal Or Veg.Fats , Oils Processed Or Waxes (0.03%)	116.16	(-83.01)	-14.09	(8.32)*	7.40	(3.92)*	1.83	(1.35)
51	Organic Chemicals (2.79%)	-286.87	(143.54)*	31.13	(15.67)*	-15.98	(7.95)*	4.67	(1.65)***
52	Inorganic Chemicals (0.42%)	-99.31	(27.17)***	8.55	(2.76)***	-1.98	(-1.35)	-2.55	(0.58)***
53	Dyeing,Tanning , Colouring Materials (0.50%)	-33.16	(-56.40)	2.86	(-5.72)	-1.54	(-2.85)	1.89	(1.05)*
54	Medicinal , Pharmace Utical Products (3.81%)	90.95	(-32.54)	-8.50	(3.46)**	2.57	(-1.75)	-0.10	(0.51)
55	Essential Oils ,Pesinoids,Plshng.,Cleang.Preps. (0.35%)	1.13	(-18.40)	-0.37	(-2.01)	0.24	(-1.06)	-0.06	(0.29)
56	Fertilizers (0.66%)	21.43	(-62.24)	-3.44	(-6.49)	2.78	(-3.26)	-2.43	(1.18)**
57	Plastics In Primary Forms (3.93%)	-337.11	(68.22)***	25.38	(7.53)***	-4.12	(-3.96)	4.83	(0.94)***
58	Plastics In Non-Primary Forms (0.32%)	62.09	(-94.01)	-13.78	(-10.80)	12.07	(5.94)*	-1.56	(1.25)

code	SITC Description	constant		$\ln Y_{EU}$		$\ln Y_{EG}$		$\ln REX$	
59	Chemical Materials , Products , N.E.S. (1.21%)	-14.31	(-37.28)	4.42	(-3.81)	-4.72	(1.85)**	1.14	(0.66)*
61	Leather,Leather Manfacture,N.E.S (0.21%)	-254.93	(51.87)***	21.99	(5.97)***	-5.92	(3.25)*	1.41	(0.67)**
62	Rubber Manufactures (0.53%)	-315.31	(72.58)***	31.63	(8.18)***	-13.45	(4.48)***	1.42	(1.01)
63	Cork , Wood Manufactures (Excl Furniture) (0.09%)	-23.07	(-39.30)	1.67	(-3.97)	-0.56	(-1.94)	0.19	(0.71)
64	Paper, Paperboard, Articles of paper (1.52%)	434.45	(234.86)*	-50.46	(26.47)*	26.73	(14.11)*	-2.11	(3.06)
65	Textile Yarn Fabrics Made-Up Art (1.65%)	-85.58	(21.04)***	8.73	(2.32)***	-3.73	(1.23)***	1.17	(0.35)***
66	Non-Metalic Mineral Mnfctrs,N.E.S. (1.17%)	-89.67	(-97.56)	7.75	(-10.53)	-2.81	(-5.51)	4.46	(1.40)***
67	Iron And Steel (4.40%)	-227.25	(44.72)***	21.49	(5.01)***	-8.27	(2.66)***	2.88	(0.59)***
68	Non-Ferrous Metals (1.61%)	-18.11	(-14.93)	1.51	(-1.51)	-0.37	(-0.75)	0.51	(0.27)*
69	Manufactures Of Metals Nes (2.09%)	-76.00	(21.11)***	4.60	(2.14)**	-0.07	(-1.07)	3.75	(0.44)***
71	Power Generating Machinery And Equipment (0.83%)	-40.72	(-116.33)	0.71	(-12.75)	1.73	(-6.77)	0.96	(2.06)
72	Mch. Industries (4.33%)	-343.96	(109.20)***	33.37	(12.16)***	-13.95	(6.38)**	3.84	(1.30)***
73	Netal Working Mchy. (.68%)	-130.85	(-88.49)	12.65	(-9.26)	-5.80	(-4.79)	3.16	(1.84)*
74	General Indus.Machinery, Equip., Parts (5.50%)	-108.75	(-75.15)	7.13	(-8.61)	0.01	(-4.71)	-1.35	(1.01)
75	Office Mch. , Automatic Data Procg (0.75%)	-216.65	(85.62)**	19.05	(9.64)*	-5.97	(-5.34)	-1.14	(1.40)
76	Telecom,Sound Record,Reproduc.Apprts.,Equp. (4.81%)	-81.18	(-112.26)	9.18	(-12.61)	-5.54	(-6.94)	2.05	(1.84)
77	Elecl.Mchy,Apprt., Appl.,Parts Thereof (2.15%)	-5.74	(-16.60)	-0.15	(-1.90)	0.15	(-1.08)	0.35	(0.32)
78	Road Vehicles (Including Air-Cushion Vehicles) (3.06%)	-53.23	(-142.58)	-0.87	(-16.18)	5.40	(-8.68)	-0.36	(1.66)
79	Other Transport Equp (0.04%)	-143.82	(80.00)*	12.01	(-8.08)	-3.16	(3.98)	-0.72	(1.46)
81	Prefabricated-Buildings-Sanitsary Plumbing (0.54%)	-136.82	(62.55)**	12.27	(6.69)*	-3.80	(3.41)	0.46	(0.95)
82	Furniture & Parts Thereof; Bedding, Mattrresses (0.32%)	-71.55	(29.24)**	5.85	(3.04)*	-1.71	(1.50)	2.67	(0.54)***
83	Travel Goods Handbags And Similar Containers (0.02%)	359.97	(-301.21)	-41.74	(-35.40)	22.35	(20.14)	-2.30	(4.27)
84	Articles Of Apparel And Clothing Accessories (0.51%)	31.04	(-26.11)	-0.91	(-2.61)	-1.10	(1.23)	-0.43	(0.39)
85	Footwear (0.01%)	180.38	(54.70)***	-13.68	(5.52)**	1.01	(2.71)	4.29	(0.98)***
87	Professional, Scientific , Controlling Instuments (1.35%)	-60.10	(-50.74)	3.45	(-5.15)	0.23	(2.56)	0.02	(0.95)
88	Photographic App. N.E.S. Clocks , Watches (0.11%)	-134.92	(-275.86)	14.53	(-31.78)	-8.24	(17.50)	4.97	(4.19)
89	Miscellaneous,Manufactured Articles N.E,.S. (1.57%)	2.98	(-24.55)	0.97	(-2.48)	-1.38	(1.22)	-1.41	(0.45)***

Trade shares for 2007Q4 are in parenthesis following each industry.
Standard errors are in parenthesis
*** Significant at the 1% significance level, ** Significant at the 5% significance level, * Significant at the 10% significance level

From Table (3.3.2), we gather that when total trade is considered between Egypt and the EU, all variables carry significant coefficients with their expected signs. The real depreciation of the Egyptian pound against the euro seems to have a long-run and favorable effect on Egypt's trade balance. Which industries contribute to this significant favorable effect? As can be seen there are 24 industries in which the real exchange rate carries a significantly positive coefficient. These are coded as: 0, 4, 6, 9, 11, 27, 32, 33, 34, 42, 51, 53, 57, 59, 61, 65, 66, 67, 68, 69, 72, 73, 82, and 85.[32] If we follow Rose and Yellen (1989, p. 67) and define the J-Curve effect as the negative short-run effect combined with the positive long-run effect, clearly the phenomenon receives support in the mentioned 24 industries. Note that these 24 industries together have almost 60% market share.[33] Note also that included among these 24 industries that are affected favorably are the two largest industries. They are petroleum and related products coded 33 with 18% market share and the gas industry coded 34 with 14% market share.

The above long-run analysis would be valid only if we establish cointegration among the variables. The results of the *F-test* for joint significance of the lagged level variables along with several other diagnostic statistics are reported in Table (3.3.3). Clearly, the calculated *F-statistic* is greater than its upper bound critical value of 3.77 in most cases. While in some cases cointegration is due to significant effects of the exchange rate, in some others cointegration is due to significance of income variables.

[32] Note that there are six other industries in which the real exchange rate carries a significant coefficient, however, with a negative sign.
[33] The market shares are reported next to the name of each industry in Table 2 and calculated as the sum of exports and imports of each industry as a percent of total exports plus total imports of Egypt.

Table 3.3.3: Diagnostic Tests

code	SITC Description	F	ECM_{t-1}		LM	RESET	CUSUM	CUSUM SQ	Adj R^2
	TOTAL	11.68	-1.08	(0.15)***	2.69	0.08	Stable	Stable	0.69
0	Live Animals Other Than Animals Division 03	5.86	-0.55	(-0.11)***	1.71	0.38	Stable	Stable	0.40
1	Meat And Meat Preparations	2.44	-0.28	(0.08)***	13.64***	3.34*	Stable	Stable	0.33
2	Dairy Products , Birds Eggs	16.06	-1.09	(0.13)***	2.52	0.09	Stable	Unstable	0.59
3	Fish Crustaceans, Molluscs, Aquatic Invertebrates Preps.	4.80	-1.01	(0.21)***	13.56***	4.47**	Stable	Stable	0.74
4	Cereals ,Cereal Preparations	5.62	-1.39	(0.28)***	2.11	0.18	Stable	Unstable	0.49
5	Vegetables , Fruit	4.41	-1.57	(0.35)***	5.51	0.08	Stable	Stable	0.90
6	Sugars, Sugar Preparations, Honey	9.07	-1.55	(0.24)***	6.43	7.45***	Stable	Stable	0.68
7	Coffee. Tea, Cocoa, Spices, Manufs.Thereof.	7.16	-0.75	(0.13)***	6.55	4.05**	Stable	Unstable	0.48
8	Feeding Stuff For Animals	16.79	-1.57	(0.18)***	4.68	0.07	Stable	Stable	0.69
9	Miscellaneous Edible Prod and Preparations	6.02	-0.71	(0.14)***	2.93	3.43*	Stable	Stable	0.55
11	Beverages	8.30	-0.83	(0.14)***	6.81	4.42**	Stable	Stable	0.46
12	Tobacco , Tobacco Manufactures	10.15	-0.86	(0.13)***	2.54	0.12	Stable	Stable	0.40
22	Oil Seeds , Oleaginous Fruits	5.05	-0.79	(0.17)***	6.41	2.14	Stable	Stable	0.34
23	Crude Rubber	4.67	-0.48	(0.10)***	3.70	0.06	Stable	Unstable	0.23
24	Cork , Wood	12.21	-0.93	(0.12)***	2.68	0.13	Stable	Stable	0.54
26	Textile Fibres, Their Wastes	7.76	-1.10	(0.19)***	9.51**	7.18***	Stable	Stable	0.63
27	Crude Fertilizers And Crude Minerals	1.61	-0.53	(0.23)**	10.95**	10.48***	Stable	Stable	0.13
28	Matalliferous Ores, Metal Scrap	8.39	-0.86	(0.14)***	2.11	1.54	Stable	Stable	0.47
29	Crude Matl.Animal Or Veg.Orign. N.E.S	3.93	-1.24	(0.29)***	23.03***	4.02**	Stable	Stable	0.84
32	Coal, Coke , Briquettes	2.93	-0.76	(0.21)***	5.99	0.85	Stable	Stable	0.50
33	Petroleum, Petroleum Products And Related Materials	9.38	-0.87	(0.14)***	4.18	0.07	Stable	Stable	0.43
34	Gas, Natural, Manufactured	7.81	-1.69	(0.29)***	2.96	5.12	Stable	Stable	0.70
42	Fixed Veg. Fats, Oils Crude Pefined	8.05	-0.83	(0.14)***	7.70	0.04	Stable	Stable	0.54
43	Animal Or Veg.Fats , Oils Processed or Waxes	11.07	-0.59	(0.08)***	2.50	0.88	Stable	Stable	0.59
51	Organic Chemicals	4.19	-0.78	(0.18)***	7.54	0.00	Stable	Stable	0.53
52	Inorganic Chemicals	7.97	-0.83	(0.14)***	11.10**	4.82**	Stable	Stable	0.67
53	Dyeing,Tanning , Colouring Materials	16.41	-1.17	(0.14)***	1.65	0.06	Stable	Unstable	0.58
54	Medicinal , Pharmace Utical Products	17.09	-1.12	(0.13)***	4.98	0.41	Stable	Stable	0.53
55	Essential Oils ,Pesinoids,Plshng.,Cleang.Preps.	3.87	-1.07	(0.26)***	4.58	0.32	Stable	Stable	0.54
56	Fertilizers	10.10	-1.06	(0.16)***	2.94	1.88	Stable	Stable	0.68
57	Plastics In Primary Forms	6.39	-1.52	(0.29)***	4.48	0.44	Stable	Unstable	0.50

code	SITC Description	*F*	ECM_{t-1}		*LM*	*RESET*	*CUSUM*	*CUSUM SQ*	*Adj* R^2
58	Plastics In Non-Primary Forms	8.25	-1.39	(0.23)***	4.52	0.01	Stable	Unstable	0.65
59	Chemical Materials , Products , N.E.S.	12.38	-0.99	(0.13)***	3.16	0.41	Stable	Stable	0.65
61	Leather,Leather Manfacture, N.E.S	8.27	-2.32	(0.37)***	4.24	1.43	Stable	Stable	0.77
62	Rubber Manufactures	5.04	-1.15	(0.24)***	5.48	0.25	Stable	Unstable	0.40
63	Cork , Wood Manufactures (Excl Furniture)	13.90	-0.90	(0.11)***	3.25	0.15	Stable	Stable	0.59
64	Paper,Paperboard,,Articles Of Paper Pulp Of Paper	4.31	-0.41	(0.09)***	6.94	3.37	Stable	Unstable	0.46
65	Textile Yarn Fabrics Made-Up Art , Related Products	5.24	-0.89	(0.18)***	2.63	0.01	Stable	Stable	0.62
66	Non-Metalic Mineral Mnfctrs,N.E.S.	3.20	-0.39	(0.10)***	2.59	2.09	Stable	Unstable	0.53
67	Iron And Steel	9.05	-1.09	(0.17)***	4.18	1.13	Stable	Stable	0.59
68	Non-Ferrous Metals	8.55	-0.74	(0.13)***	3.00	0.47	Stable	Stable	0.33
69	Manufactures Of Metals Nes	7.80	-0.88	(0.15)***	16.24***	1.05	Stable	Stable	0.43
71	Power Generating Machinery And Equipment	17.24	-1.15	(0.13)***	2.92	0.01	Stable	Stable	0.63
72	Mch. Industries	7.11	-1.27	(0.22)***	3.66	1.62	Stable	Stable	0.62
73	Netal Working Mchy.	4.50	-0.81	(0.18)***	13.15**	1.28	Stable	Stable	0.47
74	General Indus. Machinery, Equip.,Machinery Parts	9.18	-0.74	(0.11)***	5.22	1.79	Stable	Stable	0.58
75	Office Mch. , Automatic Data Procg	4.23	-0.96	(0.22)***	4.26	2.09	Stable	Stable	0.64
76	Telecom,Sound Record,Reproduc.Apprts.,Equp.	12.01	-0.99	(0.14)***	6.28	0.19	Stable	Stable	0.55
77	Elecl.Mchy,Apprt., Appl.,Parts Thereof	7.56	-2.86	(0.50)***	7.82	0.78	Stable	Stable	0.67
78	Road Vehicles (Including Air-Cushion Vehicles)	5.72	-1.12	(0.22)***	9.31	7.50***	Stable	Stable	0.61
79	Other Transport Equp	11.61	-0.86	(0.12)***	0.37	0.02	Stable	Stable	0.52
81	Prefabricated-Buildings-Sanitsary Plumbing Heating	7.30	-0.71	(0.12)***	1.38	7.56***	Stable	Stable	0.53
82	Furniture And Parts Thereof; Bedding, Mattrresses	4.26	-0.64	(0.14)***	2.74	1.26	Stable	Stable	0.75
83	Travel Goods Handbags And Similar Containers	4.11	-0.62	(0.14)***	7.00	0.23	Stable	Stable	0.58
84	Articles Of Apparel And Clothing Accessories	10.30	-0.91	(0.13)***	3.76	6.02**	Stable	Stable	0.51
85	Footwear	10.01	-0.83	(0.13)***	7.59	1.60	Stable	Stable	0.41
87	Professional,Scientific, Controlling Instuments	12.25	-0.96	(0.14)***	8.21*	2.72	Stable	Unstable	0.44
88	Photographic App. N.E.S. Clocks , Watches	5.91	-0.65	(0.12)***	6.39	2.03	Stable	Stable	0.60
89	Miscellaneous,Manufactured Articles N.E.S.	12.02	-0.93	(0.13)***	4.38	0.23	Stable	Stable	0.50

Notes: Standard errors are in parenthesis. *** indicates significance at the 1% level. ** indicates significance at the 5% significance level, and * indicates significance at the 10% level

At the 10% level of significance, the upper bound critical value of F statistic is 3.77. This comes from Pesaran *et al.* (2001, Table CI, Case III, p. 300).

Lagrange Multiplier critical value at 5% level is 9.48

RESET critical value at 5% level is 3.48

Several other statistics are also reported in Table (3.3.3). To determine the long-run adjustment of variables, following Pesaran *et al*. (2001), the long-run coefficient estimates from Table (3.3.2) are used to form an error-correction term, *ECM*.[34] After replacing the linear combination of lagged level variables in (3.3.2) by ECM_{t-1} , each model is re-estimated at optimum lags. A significantly negative coefficient obtained for ECM_{t-1} reflects adjustment toward equilibrium. As can be seen from Table (3.3.3), this coefficient is negative and highly significant in all optimum models. The size of the coefficient reflects the adjustment speed. While adjustment is slow in some industries like industry coded 1 (Live animals), it is rather fast in some others like industry coded 4 (Cereals).

Two other statistics are also reported. The *Lagrange Multiplier (LM) statistic* is used to test for serial correlation among the residuals. Since data is quarterly, it is distributed as χ^2 with four degrees of freedom. Given its critical value of 9.48, there are only eight models in which residuals suffer from autocorrelation. These models belong to industries that are coded 1, 3, 26, 27, 29, 52, 69, and 73. Ramsey's *RESET test* for misspecification is also reported. This statistic is also distributed as χ^2 but with one degree of freedom. Given the critical value of 3.84, only three industries yield statistical significance, indicating mis-specified models. These industries are coded as 78, 81, and 84.

How stable are the short-run and the long-run coefficient estimates? A common practice here is to apply CUSUM and CUSUMSQ tests of Brown et al. (1975) to the

[34] For details of this step see Bahmani-Oskooee and Tanku (2008).

residuals of each error-correction model. Since the residuals are proxies for the linear combination of short-run and long-run variables, their volatility will reflect instability of all coefficients combined. According to the cumulative sum (CUSUM) test the recursive residuals are plotted against the break points while the CUSUM of squares test (CUSUMSQ) plots the squared recursive residuals against the break points. These two statistics are then plotted within two straight lines which are bounded by a 5% significance level. If any point is beyond this 5% level, the null hypothesis of stable parameters is rejected. A summary of these tests are reported in Table (3.3.3) and clearly, almost all estimated coefficients seem to be stable.[35] Finally, we report the adjusted R^2 for each model where each model reveals a reasonable fit.

3.3.4. Summary and Conclusion

Like every other macroeconomic variable, the trade balance adjusts to currency depreciation with some lags. If a country's trade balance is deteriorating and policy makers decide to devalue their currency or allow their currency to depreciate, because of adjustment lags the trade balance still continues to deteriorate. Once adjustment lags are realized, the trade balance could improve, resulting in a pattern known as the J-Curve phenomenon.

A recent review article by Bahmani-Oskooee and Hegerty (2010) classifies all empirical studies into three categories. One group uses trade data between one country and the rest of the world while another group uses data between two countries at the

[35] For graphical presentation of these tests see Bahmani-Oskooee et al. (2005).

bilateral level. The last group, which uses data at the commodity level between two countries, is said to be free from any aggregation bias. As more and more data become available at the commodity level, this approach is the preferred approach.

In this study we test the J-Curve phenomenon between Egypt and the European Union (EU). We first test the phenomenon between the two regions using aggregate bilateral trade data. Suspecting that the results could suffer from aggregation bias, we disaggregate the trade data by industry. A total of 59 industries trade between Egypt and EU, and using quarterly data over the period 1994I-2007IV, we test the phenomenon for each industry using the bounds testing approach to cointegration and error-correction modeling. The approach not only does not require pre-unit root testing of the variables, but tests for the short-run as well as the long-run effects of currency depreciation on the trade balance. The results indicate that in 24 industries the trade balance deteriorates in the short run and improves in the long run. The two largest industries were among the 24 industries. Since its introduction in 1999 the euro has gained in value against the U.S. dollar, a reserve currency. Due to arbitrage activities in foreign exchange markets, the same has taken place against Egyptian pound. In this paper, we have identified 24 industries that trade between Europe and Egypt and that have gained by pound depreciation.

3.4. S-Curve

3.4.1. Motivation and Literature

In an attempt to improve its trade balance and its international competitiveness, a country could adhere to currency devaluation or depreciation. However, deterioration of the U.S. trade balance in 1971 despite a 15% devaluation of the dollar led Magee (1973) to present a new idea that because of adjustment lags in production and the delivery process, the effects of devaluation on the trade balance is not instantaneous. Capitalizing on this concept, Backus *et al.* (1994) introduced yet another approach to test for the short-run effects of currency depreciation on the trade balance. They demonstrated that under certain conditions such as productivity shocks, while the correlation between the current exchange rate and future trade balances could be positive, the same correlation between the current rate and past values of the trade balances could be negative. Since the plot of these correlation coefficients at various lags and leads of the trade balance resembles the letter "S", they labeled this pattern as the "S-curve". Bahmani-Oskooee and Hegerty (2010) provide a comprehensive review of the literature about both curves.

Since this paper is about Egypt, a brief review of Egypt-related studies is in order so that we can highlight the contribution of this paper. Backus *et al.* (1994) who introduced the concept tested the phenomenon for 11 OECD countries. Senhadji (1998) who considered experiences of 30 developing countries did not include Egypt in his sample. However, Parikh and Shibata (2004) who tested the S-Curve for 59 less developed countries did not find support for the S-curve in the trade between Egypt and the rest of the world. It is in this direction that we like to extend the literature by asking whether the lack of the S-curve pattern in the trade between Egypt and the rest of the world suffers from aggregation bias. To answer this question, we disaggregate the Egyptian trade flows by trading partners and by commodities. We include in our analysis the 36 industries that trade between Egypt and the U.S. and 59 industries that trade between Egypt and the EU. Data definition and sources appear in an Appendix.

3.4.2. The Methodology and Results

As mentioned earlier, the S-curve analysis is based on the cross-correlation coefficients between the trade balance and the real exchange rate. From a theoretical point of view, the two variables should be defined in a way that a positive correlation reflects an improvement in the trade balance due to exchange rate depreciation. Let us first consider the case of Egypt-U.S. trade and define the trade balance of industry i as $TB_i = (X_i – M_i)/ GDP$ where X_i is exports of industry i by Egypt to the U.S. and M_i is the imports of industry i by Egypt from the U.S. GDP is Egyptian Gross Domestic Product. All variables are in nominal terms in Egyptian pounds. The real bilateral exchange rate (REX) between the Egyptian pound and the U.S. dollar is defined as $REX = (P_{US}. NEX) / P_{EG}$ where NEX is the nominal exchange rate defined as the number of Egyptian pound per dollar, P_{US}. is the price level in the U.S. and P_{EG} is the price level in Egypt. Hence an increase in REX reflects a real depreciation of the Egyptian pound. Based on these definitions, if a real depreciation of the Egyptian pound is to improve industry i's trade balance, contemporaneous correlation between the two variables is expected to be positive. If, however, this correlation is negative, then the Harbeger-Larsen-Metzler

(HLM) effect is said to be present. Let ρ_k denote the correlation coefficient between REX and TB_{t+k}. Following Bahmani-Oskooee and Ratha (2007), we construct it as:

$$\rho_k = \frac{\sum (REX_t - \overline{REX})(TB_{t+k} - \overline{TB})}{\sqrt{\sum (REX_t - \overline{REX})^2 (TB_{t+k} - \overline{TB})^2}} \qquad (3.4.1)$$

When k takes a negative values such as -1, -2, -3, . . . the correlation coefficient is between the past values of the trade balance and the current real exchange rate. And when k takes positive values such as +1, +2, +3, etc. the correlation coefficient is between the current exchange rate and the future trade balance. The plot of ρ_k against k will yield the S-Curve. Note that to avoid spurious outcomes, we follow Backus *et al.* (1994) and use the Hodrich-Prescott (HP) filter to estimate the trend path of each time series variable. We then take the deviation of each variable from its filtered trend and use it in (3.4.1) to calculate the correlation coefficients.

Quarterly data over the period 1994I-2007IV were available on all variables involved. By allowing k to take values -6, -5, -4, -3, -2, -1, 0, +1, +2, +3, +4, +5, +6 we calculate the cross-correlation coefficients and plot them against k. As mentioned Parikh and Shibata (2004) who tested the S-curve for 59 less developed countries including Egypt, did not find support for the S-curve in the trade between Egypt and the rest of the world. Therefore, we first follow Bahmani-Oskooee and Ratha (2007) and test the phenomenon between Egypt and the U.S. using aggregate bilateral trade data. Since no support was found for the S-curve, we disaggregated the trade data between the two countries by commodity and test the S-curve pattern for 36 industries that trade between the two countries. The results are summarized in Table (3.4.1).

Table 3.4.1: Summary of the Results for Egypt-U.S. Trade

code	*SITC Description*	*Trade share in 2007*	*S-Curve Confirmed?*
00	Live animals other than animals of division 03	0.05%	Yes
02	Dairy products and birds' eggs	0.46%	
03	Fish, crustaceans, aquatic invertebrates	0.12%	Yes
04	Cereals and cereal preparations	43.06%	
05	Vegetables and fruit	0.40%	
06	Sugars, sugar preparations and honey	0.06%	
07	Coffee, tea, cocoa, spices & manufactures thereof	0.04%	Yes
09	Miscellaneous edible products and preparations	0.09%	
11	Beverages	0.002%	
12	Tobacco and tobacco manufactures	0.25%	
22	Oil-seeds and oleaginous fruits	7.20%	
24	Cork and wood	0.27%	
26	Textile fibers and their wastes	0.21%	
27	Crude fertilizers, and crude minerals	0.22%	
29	Crude animal and vegetable materials	0.18%	
33	Petroleum, petroleum products & related materials	5.45%	
42	Fixed vegetable fats and oils, crude, refined	0.05%	
52	Inorganic Chemicals	0.11%	
54	Medicinal and pharmaceutical products	1.05%	Yes
55	Essential oils & perfume materials; polishing	0.20%	Yes
56	Fertilizers (other than those of group 27)	0.85%	
59	Chemical materials and products	0.82%	
61	Leather, leather manufactures & dressed furskins	0.0003%	Yes
63	Cork and wood manufactures (excluding furniture)	0.10%	
64	Paper, paperboard and articles of paper pulp	0.67%	
65	Textile yarn, fabrics, made-up articles	0.99%	
66	Non-metallic mineral manufactures	0.40%	Yes
67	Iron and steel	0.24%	Yes
69	Manufactures of metals	0.97%	
74	General industrial machinery and equipment	3.49%	
75	Office machines and automatic data-processing	0.86%	Yes
77	Electrical machinery, apparatus & appliances	1.10%	
81	Prefabricated buildings; sanitary, plumbing	0.04%	
82	Furniture, and parts thereof; bedding, mattresses	0.44%	

84	Articles of apparel and clothing accessories	1.32%
89	Miscellaneous manufactured articles	0.93%

From Table (3.4.1), we gather that the S-curve hypothesis is only confirmed in 9 industries. Furthermore, all nine industries are small, as reflected by their trade shares in 2007 reported in the table.[36] In none of the large industries coded 4, 22, 33, and 74 the S-curve is supported. Next, we report the S-curve for the industries in which the curve received support. Figure (3.4.1) reports these nine S-curves plus the one for bilateral trade flows, which did not support the pattern. Apparently, only these nine industries will benefit from a real depreciation of the Egyptian pound.

However, the largest trading partner of Egypt is the EU rather than the U.S. in an attempt to discover more support for the S-curve we also consider the trade between Egypt and the EU. Using the same formula identified by equation (3.4.1) in which the trade balance is now defined as the trade balance of industry i which exports from Egypt to Europe and imports from Europe to Egypt and the real exchange rate is defined between Egyptian pound and euro, we calculate cross-correlation coefficients using, again, aggregate trade data between the two regions as well as for 59 industries that trade. Following the same steps, we summarize the results in Table (3.4.2) and report the curves in Figure (3.4.2).

[36] For each industry trade share is calculated as sum of exports and imports of that industry as a percent of total exports plus total imports between Egypt and the U.S.

Figure 3.4.1: The S-Curves for Nine Industries and For Total Egypt-US Trade

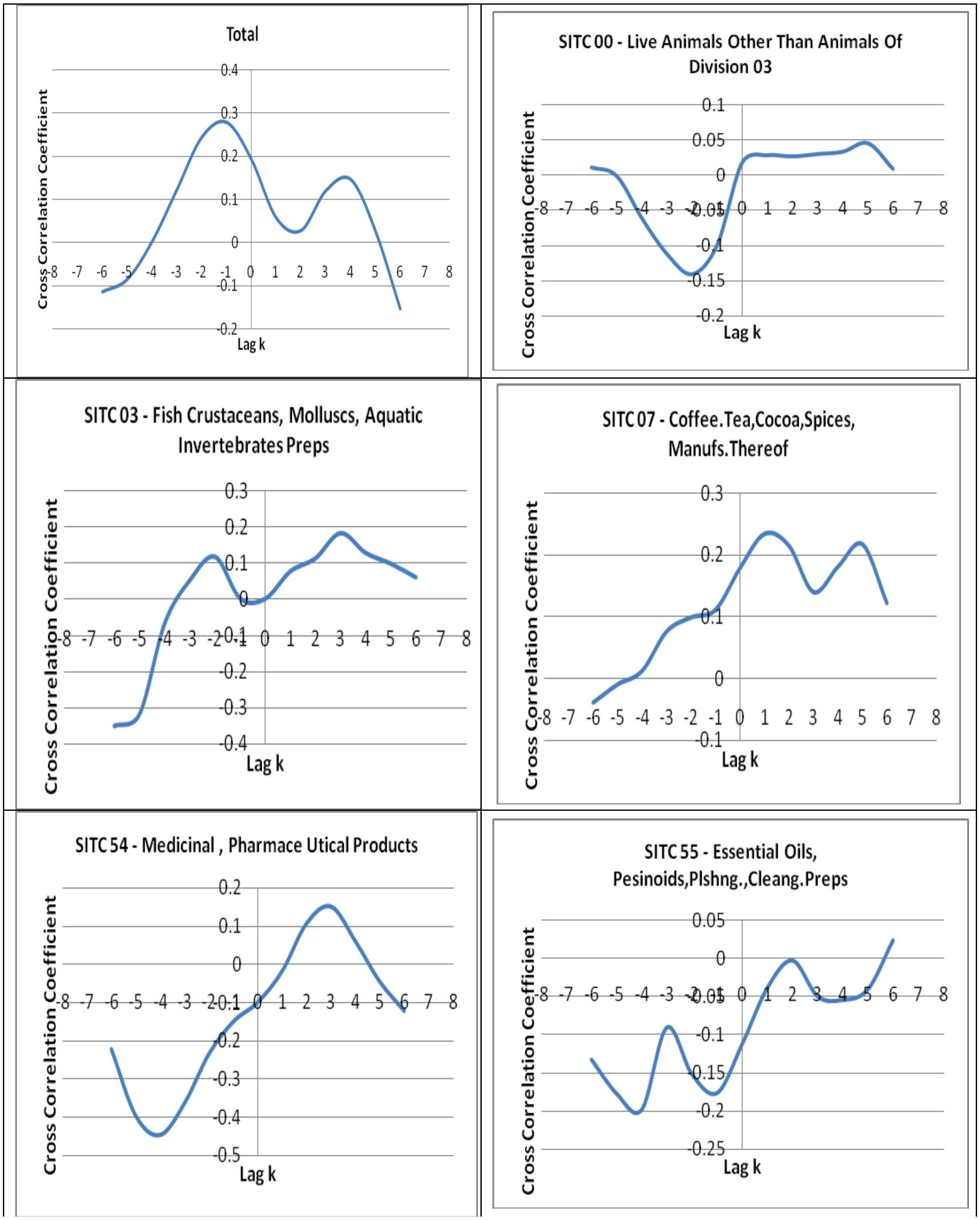


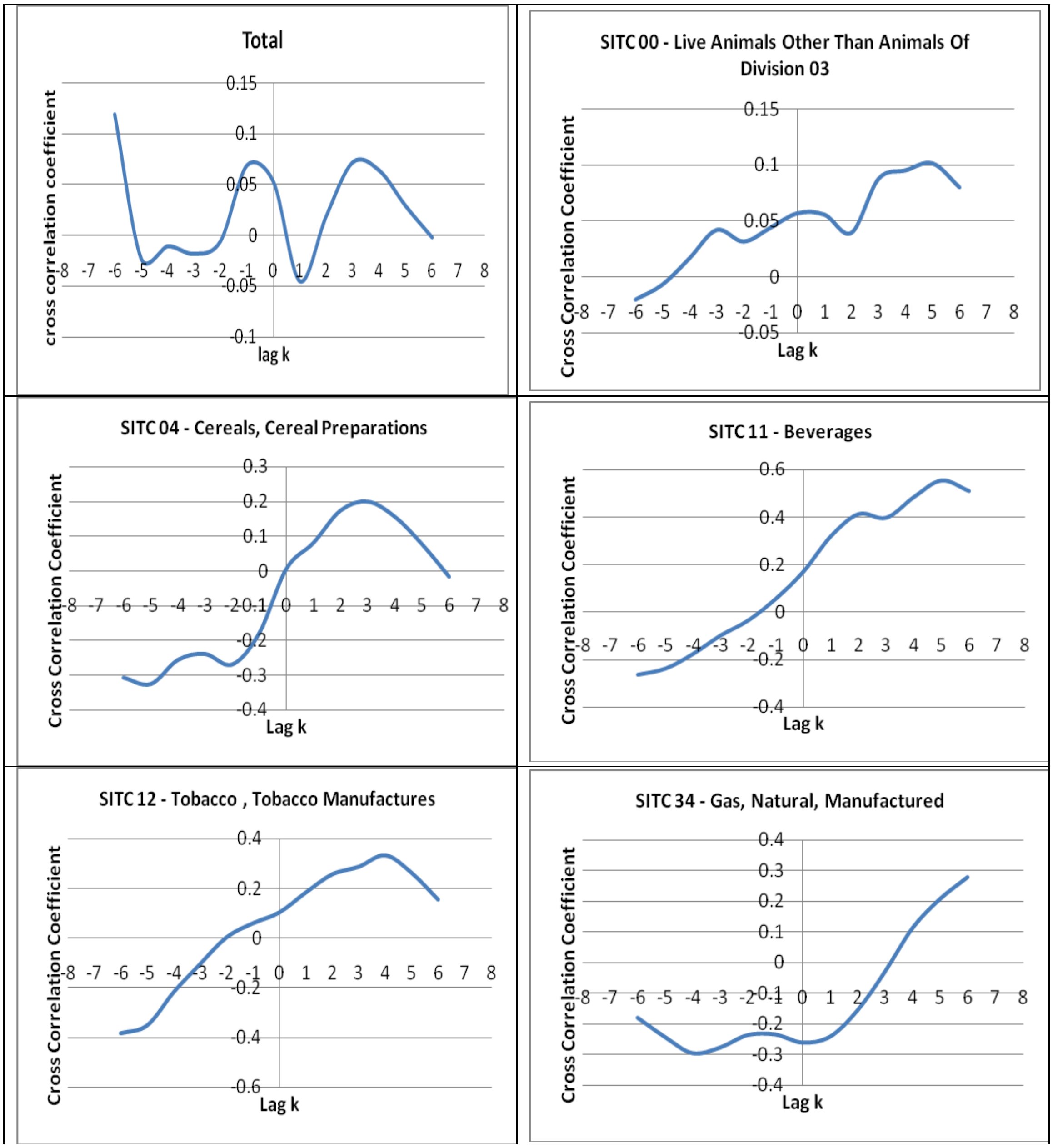
Table 3.4.2: Summary of the Results for Egypt-EU Trade

code	*SITC Description*	*Trade share in 2007*	*S-Curve Confirmed?*
00	Live animals other than animals of division 03	0.04%	Yes
01	Meat and meat preparations	0.02%	
02	Dairy products and birds' eggs	0.29%	
03	Fish, crustaceans, aquatic invertebrates	0.86%	
04	Cereals and cereal preparations	1.99%	Yes
05	Vegetables and fruit	4.04%	
06	Sugars, sugar preparations and honey	0.16%	
07	Coffee, tea, cocoa, spices & manufactures	0.13%	
08	Feeding stuff for animals	0.13%	
09	Miscellaneous edible products and preps	0.52%	
11	Beverages	0.02%	Yes
12	Tobacco and tobacco manufactures	0.38%	Yes
22	Oil-seeds and oleaginous fruits	0.05%	
23	Crude Rubber	0.13%	
24	Cork and wood	2.26%	
26	Textile fibers and their wastes	0.47%	
27	Crude fertilizers, and crude minerals	0.49%	
28	Metalliferous ores and metal scrap	1.26%	
29	Crude animal and vegetable materials	0.25%	
32	Coal, coke and briquettes	0.27%	
33	Petroleum, petroleum products	18.19%	
34	Gas, natural and manufactured	14.09%	Yes
42	Fixed vegetable fats and oils, crude, refined	0.03%	
43	Animal or vegetable fats and oils, processed	0.03%	
51	Organic Chemicals	2.79%	
52	Inorganic Chemicals	0.42%	
53	Dyeing, tanning and coloring materials	0.50%	
54	Medicinal and pharmaceutical products	3.81%	Yes
55	Essential oils & perfume materials; polishing	0.35%	
56	Fertilizers (other than those of group 27)	0.66%	
57	Plastics in primary forms	3.93%	
58	Plastics in non-primary forms	0.32%	Yes
59	Chemical materials and products	1.21%	
61	Leather, leather manufactures & dressed furskins	0.21%	
62	Rubber manufactures	0.53%	
63	Cork and wood manufactures	0.09%	
64	Paper, paperboard and articles of paper pulp	1.52%	
65	Textile yarn, fabrics, made-up articles	1.65%	
66	Non-metallic mineral manufactures	1.17%	Yes
67	Iron and steel	4.40%	
68	Non-ferrous metals	1.61%	
69	Manufactures of metals	2.09%	

71	Power-generating machinery and equipment	0.83%	
72	Machinery specialized for particular industries	4.33%	
73	Metalworking machinery	0.68%	
74	General industrial machinery and equipment	5.50%	
75	Office machines & automatic data-processing	0.75%	
76	Telecommunications and sound-recording	4.81%	
77	Electrical machinery, apparatus & appliances	2.15%	
78	Road vehicles (including air-cushion vehicles)	3.06%	
79	Other transport equipment	0.04%	Yes
81	Prefabricated buildings; sanitary, plumbing	0.54%	Yes
82	Furniture, and parts thereof; bedding, mattresses	0.32%	
83	Travel goods, handbags and similar containers	0.02%	
84	Articles of apparel and clothing accessories	0.51%	
85	Footwear	0.01%	
87	Professional, scientific and controlling instr.	1.35%	
88	Photographic apparatus, equipment and supplies	0.11%	
89	Miscellaneous manufactured articles	1.57%	

From Table (3.4.2), it appears that the S-curve receives support only in 10 industries. However, this time there are at least three large industries that conform to the pattern. They are industries coded 4, 34, and 54. Obviously, if S-curve is supported only in 10 out of 59 cases, we would not expect to find the pattern for the aggregate data. Indeed, this is the case from Figure (3.4.2) where no support is found when aggregate bilateral data are used to produce the S-curve. Since the 10 industries engage in little over 22% of the trade between the two regions, we may conclude that only 22% of the trade will be affected by a real depreciation of the Egyptian pound against the euro and these 10 industries coded 0, 4, 11, 12, 34, 54, 58, 66, 79, and 81 will be beneficiaries.

Figure 3.4.2: The S-Curves for 10 Industries and For Total Egypt-EU Trade



3.4.3. Summary and Conclusion

The S-curve hypothesis asserts that due to adjustment lags, depreciation improves the trade balance in the future. One previous study tested the S-curve using aggregate trade data between each of the 59 developing countries and the rest of the world. In the results for Egypt, there was no support for the S-curve. We wonder if the lack of support for the S-curve in the case of Egypt is due to aggregation bias. To this end we disaggregated Egypt's trade data by her trading partners and tested for the S-curve pattern using quarterly data over the period 1994I-2007IV between Egypt and the U.S. in one relation and between Egypt and the EU in another relation. Since we found no support for the S-curve in either case using aggregate bilateral trade data, we disaggregated bilateral trade flows by industry and tested the phenomenon at industry level.

Over the same period of analysis, data were available for 36 industries that trade between Egypt and the U.S. and 59 industries that trade between Egypt and the EU. While the 36 industries engage in 73% of the trade between Egypt and the U.S., the 59 industries engage in almost 100% of the trade between Egypt and the EU. Support for the S-curve was limited to nine industries in the Egypt-U.S. trade and 10 industries in the Egypt-EU trade. Furthermore, while all nine industries in the first case were small, there were two large industries in the latter case. The support for the S-curve in a total of 19 out of 95 industries imply that only these 19 industries will benefit from currency depreciation or devaluation. Since most of the industries are small, Egypt cannot improve its overall trade balance by devaluing Egyptian pound.

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Appendix
Data Definition and Sources

Quarterly data over 1994Q1-2007Q4 are used to carry out the empirical analysis. The data sources are as follows:

a. Central Agency for Public Mobilization and Statistics (CAPMAS), Arab Republic of Egypt.

b. EuroStat Online Database

c. Ministry of Economic Development, Arab Republic of Egypt.

d. International Financial Statistics IMF (CD-ROM)

Variables:

M_i = For each commodity i, *M* is the volume of Egyptian imports from the European Union. It is defined as the ratio of the value of Egyptian imports from the European Union (EU) over the respective import price of commodity i. The data for both variables and for all 59 industries come from source a.

X_i = For each commodity i, *X* is volume of Egyptian exports to the European Union. It is defined as the ratio of value of Egyptian exports to the European Union (EU) over the respective export price of commodity i. The data for both variables and for all 59 industries come from source a.

Y_{EU} = The European Union real GDP. The data come from source b.

Y_{EG} = Egyptian real GDP. The data come from source c.

PM_i / PD_{EG} = For each commodity i, *PM* is defined as import price of commodity i and PD_{EG} is the price level in Egypt. The import price data for all 59 industries come from source a, while the CPI data (used as a proxy for PD_{EG}) come from source d.

***PX_i* / PD_{EU}** = For each commodity i, *PX* is defined as export price of commodity i and PD_{EU} the price level in EU. The export price data for all 59 industries come from source a, while the CPI data (used as a proxy for PD_{EU}) come from source d.

TB_i = For each commodity i, TB_i is defined as $(X_i – M_i)$/ GDP where X_i is Egypt's export of industry i to the U.S.; M_i is the same industry's imports from the U.S. and GDP is Egypt's Gross Domestic Product. They are all in nominal terms in terms of Egyptian pound. When we used data from 59 industries that traded between Egypt and EU, the U.S. was replaced by EU.

REX = Real bilateral exchange rate between the Egyptian pound and the U.S. dollar. It is defined as (P_{US}.*NEX*/P_{EG}) where P_{US} is the price level in U.S., *NEX* is the nominal bilateral exchange rate defined as number of Egyptian pounds per U.S. dollar, and P_{EG} is the price level in Egypt. Thus, an increase in *REX* reflects a real depreciation of the Egyptian pound. When the analysis was shifted to the trade between Egypt and EU, REX was defined as (P_{EU}.*NEX*/P_{EG}) where P_{EU} is the price level in euro zone and *NEX* is the nominal bilateral exchange rate defined as number of Egyptian pounds per euro.

AMR SADEK HOSNY May 2013

Office Northwest Quadrant Building B,
Room 4428, Department of Economics,
UW-Milwaukee, Milwaukee, WI 53201
Office Phone (414) 229-4375
e-mail amrsadek@uwm.edu

EDUCATION:

2008 – 2013 : *Ph.D. Economics*, University of Wisconsin-Milwaukee (UWM)
Dissertation: Essays in Open-Economy Macroeconomics

2001 – 2005 : *B. Commerce*, Business Administration,
Ain Shams University, Egypt.

RESEARCH AND TEACHING INTERESTS:

International Macro/Finance, International Trade, Monetary Economics, Economic Growth and Development, Applied Econometrics

PUBLICATIONS:

Bahmani-Oskooee, Mohsen and **Amr S. Hosny**. Long-Run Price Elasticities and the Marshall-Lerner Condition: Evidence from Egypt-EU Commodity Trade. forthcoming in *European Journal of Development Research*.

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PAPERS UNDER REVIEW:

Bahmani-Oskooee, Mohsen, **Amr S. Hosny** and Narayan K. Kishor. Understanding the Dynamics of the Macroeconomic Trilemma in History (Job Market Paper)

Hosny, Amr S. Do Fixed Exchange Rates Cause More Trade?

Hosny, Amr S. and Hamid Mohtadi. Inflation, Financial Intermediation and Growth: Case of Egypt.

Bahmani-Oskooee, Mohsen and **Amr S. Hosny**. Price and Income Elasticities: Evidence from Commodity Trade between the U.S. and Egypt.

Hosny, Amr S. Does Inflation Targeting Lower Inflation? If Yes, then When?

Amr S. Hosny. When Do Currency Unions Increase Trade?

Hosny, Amr S., Hamid Mohtadi and Magda Kandil. Does Egypt's Revolution Reveal Its Underlying Constraints and Strengths? A Growth Diagnosis Sectoral Approach.

RESEARCH IN PROGRESS:

Bahmani-Oskooee, Mohsen, **Amr S. Hosny** and Narayan K. Kishor. The Exchange Rate Disconnect Puzzle Revisited.

Hosny, Amr S. and Lucy Qian Liu. Understanding Inflation in Egypt.

Bahmani-Oskooee, Mohsen and **Amr S. Hosny**. Does the Orcutt Hypothesis Hold? Evidence from Commodity Trade between Egypt and the U.S.

Bahmani-Oskooee, Mohsen and **Amr S. Hosny**. Trade Responsiveness to Changes in the Exchange Rate and Prices: Evidence from Commodity Trade between Egypt-EU.

EMPLOYMENT & SUMMER INTERNSHIPS:

- Summer 2012 : *Fund Internship Program (FIP),* Middle East & Central Asia Department, International Monetary Fund (IMF), Washington, D.C.
- 2009 - present : *Graduate Teaching Assistant*, University of Wisconsin-Milwaukee (UWM), Milwaukee, WI.
- 2005 - 2008 : *Research Analyst*, Egyptian Center for Economic Studies (ECES), Cairo, Egypt.
- Summer 2004 : *Economic Research Forum* for Arab Countries, Iran and Turkey (ERF), Cairo, Egypt.

REFEREE:

International Economic Journal, Bulletin of Economic Research

MEMBERSHIP:

American Economic Association, Midwest Economics Association, Southern Economic Association, Middle East Economic Association

SKILLS:

Languages: Arabic, English
Computer Software: STATA, MICROFIT, EVIEWS, GAUSS

COURSES TAUGHT AT UW-MILWAUKEE:

Instructor:
Principles of Economics (Fall09, Spring10)
Principles of Microeconomics (Summer10, Fall10)
Economic Development (Spring11, Fall11, Fall12)
International Economics (Spring12, Fall12, Spring13)

Teaching Assistant:
Principles of Economics (Fall09, Spring12)
Economic Development (Fall10)
Principles of Macroeconomics (Spring11)
International Economics (online) (Spring13)

ACADEMIC AWARDS:

- Graduate Student Travel Award, *UW-Milwaukee*, Spring 2012, Spring 2010
- Awarded the "Ideal Student" of *Faculty of Commerce*, *Ain Shams University*, *Egypt* for the academic year 2003-2004.
- Awarded the "Ideal Student" of *Ain Shams University*, *Egypt* for the academic year 2003-2004.

REFERENCES:

Mohsen Bahmani-Oskooee	(414) 229-4334	bahmani@uwm.edu
Narayan K. Kishor	(414) 229-6425	kishor@uwm.edu
Hamid Mohtadi	(414) 229-5334	mohtadi@uwm.edu
Antonio Galvao, Jr.	(414) 229-4429	agalvao@uwm.edu
Rebecca Neumann	(414) 229-4347	rneumann@uwm.edu

Address: 2025 E. Newport Ave., Northwest Quadrant Building B, P.O. Box 413,
Department of Economics, University of Wisconsin-Milwaukee,
Milwaukee, WI 53201